

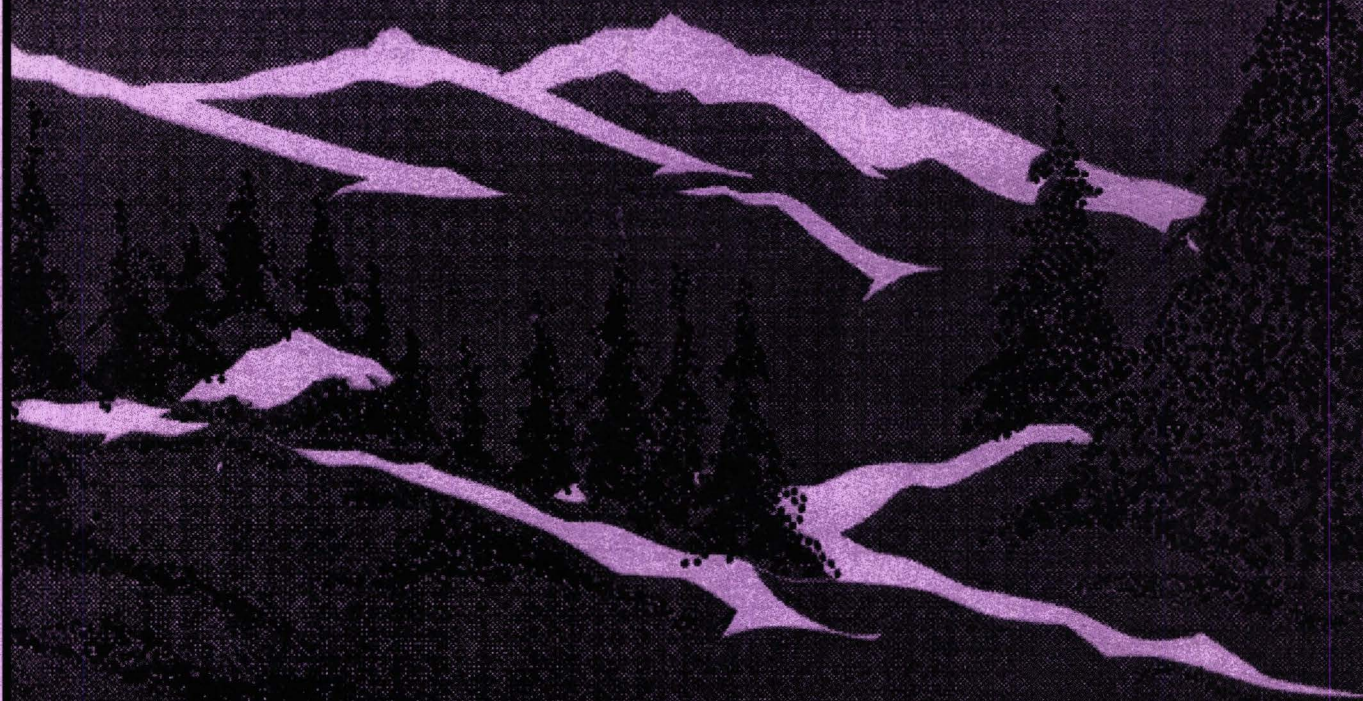
SB
761
-W7
R6
NO. 00-05

Forest Health Management

SPRUCE BEETLE EVALUATION - 1999

HAFNS PEAK/BEARS EARS RANGER DISTRICT & SURROUNDING AREAS

MEDICINE BOW - ROUTT NATIONAL FORESTS, COLORADO



United States
Department of
Agriculture

Renewable Resources
Forest Health Management

Forest Service
Rocky Mountain Region
Denver, Colorado



The United States Department of Agriculture (USDA) prohibits discrimination on the basis of race, color, national origin, sex, religion, age, disability, political beliefs, and marital status (not all basis apply to all programs). Persons with disabilities who require alternative means for communication of program information (Braille, large print, audio tape, etc.) should contact the USDA Office of Communications at (202) 720-2791.

To file a complaint, write the Secretary of Agriculture, U.S. Department of Agriculture, Washington, DC 20250, or call (800) 245-6340 (Voice), or (202) 720-1127 (TDD). USDA is an equal employment opportunity employer.

SPRUCE BEETLE EVALUATION - 1999
HAHNS PEAK/BEARS EARS RANGER DISTRICT & SURROUNDING AREAS
MEDICINE BOW – ROUTT NATIONAL FORESTS, COLORADO

National FS Library
USDA Forest Service

JUL 15 2011

240 W Horpelt Rd
Fort Collins CO 80526

SPRUCE BEETLE EVALUATION - 1999

HAHNS PEAK/BEARS EARS RANGER DISTRICT & SURROUNDING AREAS MEDICINE BOW – ROUTT NATIONAL FORESTS, COLORADO

Biological Evaluation R2-00-05

By: Willis C. Schaupp, Jr.
Willis C. Schaupp, Jr.

Entomologist, Lakewood Service Center, Forest Health Management

And: Michelle S. Frank
Michelle S. Frank

Forest Health Monitoring Coordinator, Forest Health Management

Approved By: Frank Cross
Frank Cross

Group Leader, Forest Health Management

October 2000

USDA Forest Service

Renewable Resources

Rocky Mountain Region

P. O. Box 25127

Denver, CO 80225-0127

CONTENTS

CONTENTS	vii
LIST OF MAPS	viii
LIST OF TABLES	viii
LIST OF FIGURES	viii
SUMMARY	1
ACKNOWLEDGMENTS	1
INTRODUCTION	2
The Wind Events and Forest Health Management	2
The Evaluation Focus	2
The Spruce Beetle	2
The Context of the Routt Divide Blowdown	4
Monitoring Actions	4
The Purpose and Scope of Monitoring and Evaluation Actions	4
METHODS	5
Aerial Survey	5
Pheromone Trapping	5
Extent Survey	6
Brood Sampling	6
Emergence Cage	7
RESULTS AND CONCLUSIONS	7
Aerial Survey	7
Pheromone Trapping	7
Extent Survey	12
Brood Sampling	19
Emergence Cage and “One Year” Beetles	24
DISCUSSION	25
ENDEMIC STATUS IN STANDING TREES	25
BEETLES BEGINNING TO EXIT WINDTHROW	25
CHANGE IN ENDEMIC STATUS EXPECTED	28
RECOMMENDATIONS AND ACTIONS TAKEN	28
LITERATURE CITED	30

APPENDIX 1

ACTION ALTERNATIVES AGAINST SPRUCE BEETLE	31
MANAGEMENT STRATEGIES	31
TREATMENT OPTIONS	31
Silvicultural treatment	31
Cultural treatment.....	33
Chemical.....	34
REFERENCES	35

LIST OF MAPS

Map 1. Location of Evaluation Area	3
Map 2. Spruce Beetle Extent Survey Locations	14
Map 3. Spruce Beetle Extent Survey Locations – Northwestern Inset (Bears Ears Area)	15
Map 4. Spruce Beetle Extent Survey Locations – Northeastern Inset.....	16
Map 5. Spruce Beetle Extent Survey Locations – Southern Inset.....	17

LIST OF TABLES

Table 1. Spruce Beetle Captures by Location 1999.....	8
Table 2. Extent Survey Data	12
Table 3. 1998 Extent Survey Locations	18
Table 4. Spruce Beetle Brood Density	20
Table 5. Effects of Treatments in 1999	27

LIST OF FIGURES

Figure 1. Weekly Spruce Beetle Captures 1999	9
Figure 2. Spruce Beetle Captures - Lindgren Trap.....	11
Figure 3. Average Brood Density by Location	21
Figure 4. Brood Density by Log Surface and Life Stage, Buffalo Pass	22
Figure 5. Brood Density by Log Surface and Life Stage, Bears Ears	23
Figure 6. Brood Density by Log Surface and Life Stage, Steamboat Ski Area	24

SUMMARY

This is the second in a series of biological evaluations necessitated by the 1997 windstorm on the Medicine Bow - Routt National Forest and surrounding areas in southern Wyoming and northern Colorado. The October 1997, windstorm is known as the Routt Divide Blowdown. The mapped portion of the Routt Divide Blowdown is approximately 13,000 acres, although the total extent of windthrow is larger. Most of this blowdown occurred on the Hahns Peak/Bears Ears Ranger District in the spruce/fir forest.

Survey and monitoring of the spruce beetle on the Hahns Peak/Bears Ears Ranger District and surrounding areas continued in 1999 and is expected to continue as long as necessary. Survey and monitoring techniques were aerial survey, pheromone trapping, extent surveys, and brood sampling.

Since the Routt Divide Blowdown, the spruce beetle (*Dendroctonus rufipennis*) has been utilizing fallen spruce trees for breeding material. During the 1999 field season, spruce beetle populations increased within and occupied more of this breeding material. Their populations were dense and could be found in almost any patch of blowdown surveyed. In addition, some beetles were maturing in one year instead of two. General locations of concern identified by survey and sampling include the Steamboat Springs Ski Area, the Buffalo Pass corridor, the upper Elk River drainage, the area around Floyd Peak, and the Elkhead Mountains.

Suppression actions and the preparation of an environmental impact statement are underway, aimed at this developing problem. The recommendations from the first biological evaluation (Schaupp et al. 1999) are being implemented. This evaluation describes action alternatives to mitigate spruce beetle impacts and makes additional recommendations.

The susceptible condition of many of the spruce stands on the Hahns Peak/Bears Ears Ranger District, together with continued windthrow and standing damaged trees, has created more potential host material for beetle populations. Spruce beetle populations will probably increase within this additional windthrow. In 2000, spruce beetle populations are expected to begin to exit the windthrow and to attack the nearby forest, killing green spruce trees. Small areas of standing tree mortality are expected, creating incipient epidemics. Localized spruce beetle epidemics could result. The exact extent, intensity, and duration of such events cannot be predicted at present with absolute certainty. Based on what we know about spruce beetle, the eventual scale of these predicted events might cover one or more landscapes and result in significant spruce mortality and associated impacts.

Management efforts can locally mitigate spruce beetle impacts to varying degrees, but stopping a landscape-level spruce beetle epidemic once it has begun is almost impossible. However, incipient epidemics can be controlled if proper suppression and prevention activities are initiated before these epidemics reach landscape proportions.

ACKNOWLEDGMENTS

Thanks and praise are due the many employees from the Medicine Bow - Routt National Forest, the Forest Health Management group, and the Steamboat Ski and Resort Corporation who worked on this project, whether in the forest or the office. Special commendation is made to the Gunnison Service Center, Forest Health Management, for providing field assistance on short notice. The authors are very grateful for improvements to this evaluation due to thorough and timely reviews by John Schmid, Roy Mask, and Steve Munson. John Schmid's significant and continuing contributions require special thanks. His availability, willingness to help, expert knowledge, and published research are invaluable to us.

INTRODUCTION

THE WIND EVENTS AND FOREST HEALTH MANAGEMENT

Several major episodes of windthrow on the Medicine Bow - Routt National Forests in 1996 and 1997 have resulted in an unusually large acreage of blowdown, predominantly in the spruce/fir forest cover type. Additional blowdown has been documented on these National Forests and other lands in Colorado and southern Wyoming in 1998 and 1999. The potential for significant forest insect impacts as a result of these windthrow events prompts the continuing involvement of the Forest Health Management (FHM) group of the USDA Forest Service. Forest Health Management is responsible for monitoring and evaluating forest insect and disease populations, and for describing the full range of responses and probable impacts, consistent with land management objectives. FHM will conduct these activities until such time as it is clear that no major forest insect impacts may occur as a result of these windthrow events. This biological evaluation is the second in a series.

THE EVALUATION FOCUS

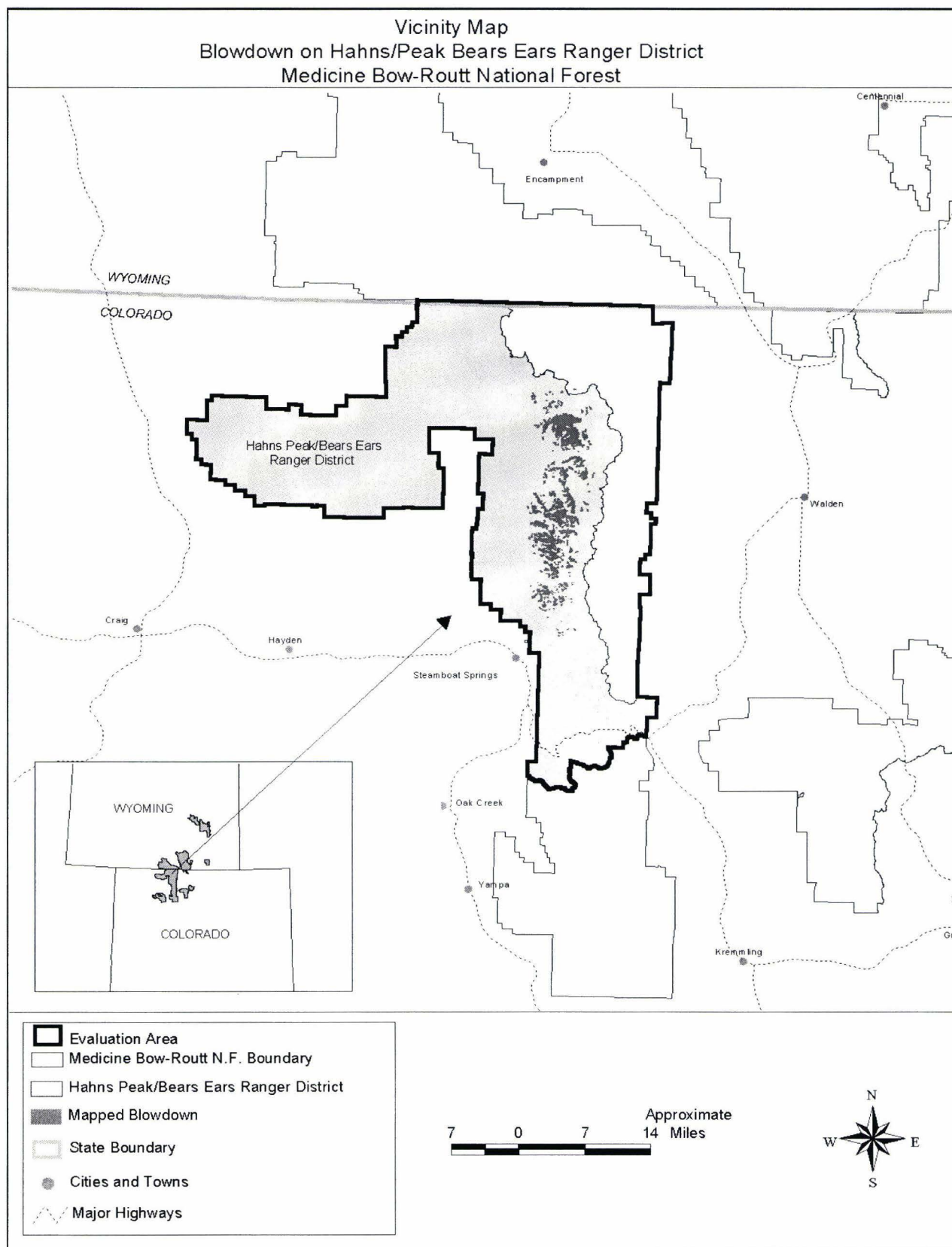
The focus of this biological evaluation is on the largest of these windthrow events, referred to as the "Routt Divide Blowdown" (Map 1). On October 25, 1997, winds estimated to be in excess of 120 miles per hour uprooted a large number of trees on the Medicine Bow - Routt National Forests. Approximately 13,000 acres of blowdown have been mapped in Colorado, primarily on the west side of the Continental Divide in the Sierra Madre, Parks, and Gore mountain ranges north of US Highway 40. Most of the affected land is publicly owned and is administered by the Hahns Peak/Bears Ears Ranger District, Medicine Bow - Routt National Forest. Approximately 8,000 acres of the Routt Divide Blowdown is within the Mt. Zirkel Wilderness Area. Many of these windthrown trees maintained root contact. Additional blowdown has occurred and will probably continue to occur, especially along the periphery of the previously created openings. Smaller areas of blowdown not previously mapped have been identified. The total impacted area is greater than the acreage mapped thus far.

One other blowdown event is mentioned in this evaluation. The Walton Creek Blowdown occurred in September 1997, a month prior to the Routt Divide Blowdown. The affected landscape is within the Hahns Peak/Bears Ears Ranger District, approximately 11 miles southeast of Steamboat Springs and at the southern extent of the Routt Divide Blowdown. The Walton Creek Blowdown covered one patch of about 3 acres.

THE SPRUCE BEETLE

The spruce beetle, *Dendroctonus rufipennis* [Kirby] (Order Coleoptera; Family Scolytidae), is the principal forest insect of concern in these blowdown areas. Normally, this native beetle is present in small numbers in weakened or windthrown trees, large pieces of logging slash, and fresh stumps. Individual or small, scattered groups of standing trees may be killed, creating snags and gaps in the forest canopy. Natural enemies, weather, competition, and other factors combine to keep beetle populations at low levels.

Sporadic spruce beetle outbreaks have killed extensive areas in parts of western North America, including Alaska, western Canada, Colorado, Idaho, Montana, and Utah (Holsten et al. 1999). Such outbreaks commonly develop in windthrown timber. Spruce beetle populations can increase dramatically within windthrow, from which they emerge to attack and kill standing, living trees. Like fire and wind, the spruce beetle is a natural, though destructive, means for recycling old forests and for making way for new forests (Furniss and Carolin 1977). The spruce beetle is the principal biotic agent that can create landscape level disturbances in the spruce forests of western North America (Holsten et al. 1999).



Map 1. Location of Evaluation Area

THE CONTEXT OF THE ROUTT DIVIDE BLOWDOWN

Spruce beetle epidemics are thought to occur every 100 – 300 years. Within one area of about 8,600 acres on the White River National Forest, three spruce beetle epidemics were evident since 1700 (Veblen et al. 1994). As determined from this data, the time interval between epidemics in a particular stand is 116.5 years. This time interval is considered reasonable by Schmid and Mata (1996), who comment that the interval could be longer if the stand was completely killed by the previous epidemic and shorter if the previous epidemic caused limited spruce mortality. As determined in the same study on the White River National Forest, the time interval during which all stands in an area are affected by epidemics is 259 years (Veblen et al. 1994). The recorded landscape scale outbreak history of spruce beetle in Colorado was described in evaluation R2-99-08 (Schaupp et al. 1999). The return interval of multiple stand epidemics is dependent upon large acreages of spruce growing into an old, dense condition, susceptible to spruce beetle, and upon the occurrence of a triggering disturbance, such as windthrow, that provides the spruce beetle population the opportunity to increase from its endemic level (Schmid and Frye 1977).

As spruce stands age, it is reasonable to expect that the endemic spruce beetle population size will slowly increase, because more suitable host material becomes available. Blowdown and tree breakage becomes increasingly common in older spruce stands, as stand structure becomes fragmented and more diverse. The number of spruce weakened by root disease and other factors also increases with stand age. In effect, as spruce forests age, the probability of a large-scale spruce beetle outbreak increases (Schmid and Mata 1996).

The Routt Divide Blowdown is but one of a number of recent blowdown events in Colorado and Wyoming. This underscores the fact that much of the spruce/fir forest in these States is mature to very old and increasingly near to the time when a disturbance will “reset the clock,” resulting in a younger-aged forests. The context of the Routt Divide Blowdown is that it is but one of several places in Colorado and Wyoming where landscape scale spruce beetle outbreaks are increasingly likely.

MONITORING ACTIONS

Several actions have been taken by Forest Health Management to monitor and evaluate spruce beetle populations on the Hahns Peak/Bears Ears Ranger District. These actions include the following: aerial survey to detect recent tree mortality and blowdown; monitoring beetle flights by deploying spruce beetle pheromone traps; conducting an “extent survey” to determine the spatial distribution of spruce beetle across the blowdown; and conducting spruce beetle brood sampling to determine the density and predominant life stages of spruce beetle present in select areas of the blowdown.

THE PURPOSE AND SCOPE OF MONITORING AND EVALUATION ACTIONS

All of the monitoring and evaluation actions by Forest Health Management attempt to determine spruce beetle population locations and trends. This requires sampling portions of the resident beetle populations. When sampling, the need for accurate, intensive information about any one area may conflict with the need for approximate, extensive information about many areas. The timely allocation of finite resources and sampling effort must strike a balance between these needs. Fortunately, there are sampling plans and protocols for spruce beetles that have been rigorously developed by the research community. However, few such protocols and plans have been statistically validated in the field following their development, and some such protocols and plans are too intensive or time-consuming to use over large areas.

For this evaluation, the size of the affected area is too vast to sample with significant precision such that statistically valid inferences are possible with high levels of confidence. The mapped portions of the Routt Divide Blowdown, an area of 13,000 acres, would be roughly 20 miles long and one mile wide if it were in one patch and that patch would still be a disorderly tangle, often several logs deep. The variation among trees within a windthrown patch and also between windthrown patches is large enough that a huge number of samples would be required to achieve high levels of confidence and precision. This conflict of needs --- precision versus extent --- is not unique to the Routt Divide Blowdown situation.

EXTENT SURVEY

The survey for spruce beetle infestation in down trees across the spatial extent of the blowdown was expanded in 1999 to include many more sites than in 1998 (Maps 2-5). The extent survey was conducted by FHM and Medicine Bow-Routt National Forest staff. The survey was conducted from June through October, although most of the work was completed in August. The Medicine Bow-Routt National Forest staff was trained in the field during the week of July 26, 1999 by Forest Health Management staff to help accomplish this survey. Data were recorded on sheets specifically designed for the project.

Extent surveys provide basic "presence/absence" information about spruce beetle occupancy of windthrow across the entire blowdown area. This information indicates the expected scale of future spruce beetle activity and helps guide more intensive sampling efforts in areas of concern. Patches of windthrow identified by aerial survey or aerial photography were candidates for examination. In addition, unmapped blowdown patches discovered during ground activities were also surveyed.

Acreage of each surveyed patch was estimated. After estimating acreage, trees within each patch were examined for spruce beetles. A total of 10 spruce trees per patch was established as the minimum sample size. For blowdown patches of 10 or more acres, one additional tree was to be added to the minimum sample for each acre above 10 acres, up to a maximum of 100 trees per patch. Examined trees were distributed as evenly as possible around the perimeter of a blowdown patch. Individual windthrown spruce were examined for the presence of spruce beetle by chopping into the tree and examining the phloem or inner bark in at least three separate spots along the trunk where the diameter was 10 inches or more. The examination focused on the shaded portions of the stem. Examination usually began with chopping near the root collar, continued visually up the stem to near the midpoint, where more chopping was done, and then moved similarly to near the top or a 10 inch diameter area, where a third area was chopped. A visual search for external signs of infestation was also performed.

Once spruce beetle infestation was confirmed in a tree by identifying galleries or insects, the surveyor moved to another tree. Information on spruce beetle life stages encountered, the presence of *Ips* beetles, the relative density of *Ips* beetle galleries, and the relative moisture level of the phloem, as well as any additional comments, were noted on data sheets.

Fourteen locations used in the 1998 extent survey were resurveyed in 1999, using the protocol described above. A different set of trees was examined during this second visit. In this way, it was thought that the methods could be evaluated and changes in spruce beetle status detected.

BROOD SAMPLING

Brood sampling of spruce beetle populations was conducted according to the 'Biological Evaluation Procedures' section of Schmid (1981, page 4). One set of three 6 inch by 6 inch bark samples was cut from anywhere along the stem of the infested portion of each windthrown sample tree, excluding 5 feet at each end and provided the tree diameter was 10 or more inches where samples were taken. Each set consisted of one 6 inch by 6 inch bark section cut from the top, the lateral, and the bottom surface of each sample tree. An effort was made to take the bottom sample near the base of the tree, the lateral sample about midway along the infested length, and the top sample near the upper end of the infested length along the tree stem. This was done to provide consistency and to account for the spruce beetle's preference for shade. Each bark section was carefully removed with a chisel or hatchet. Cheesecloth ground covers placed under the sample tree were used to collect and prevent the loss of insects as the sample was removed. Samples were processed in the field. Data include the number of spruce beetles by life stage and associated organisms such as *Ips* beetles and natural enemies. The infested length and diameter at the midpoint of the infested length was recorded for each sample tree.

Neither the total number or diameter at infestation midpoint of all infested trees per windthrow patch nor the average diameter at breast height of the surrounding, standing trees was estimated, contrary to the biological evaluation procedures described by Schmid (1981). Instead, only windthrow that was sampled was

The following table shows spruce beetle captures in 16-funnel Lindgren pheromone traps using the two-component lure on the Medicine Bow - Routt National Forests, Colorado and Wyoming, in 1999. Unless noted, locations are within the Hahns Peak/Bears Ears Ranger District.

Table 1. Spruce Beetle Captures by Location 1999

Location of Pheromone Trap	Township (North)	Range (West)	Section	Elevation (in feet)	Total Spruce Beetles Caught
Dunkley Pass (Yampa RD *)	3	87	27	9,640	**
Walton Creek Campground	5	83	23	9,560	3
Mt. Werner	6	84	25	10,320	23
Sawmill TS * (Parks RD)	6	82	8	9,240	0
Mad Creek	7	85	12	7,520	3
Floyd Peak	9	84	27	9,320	304
Reed Creek ++	9	84	2	8,640	11
3-Island Trail Head	9	83	9	8,440	58
Seedhouse	9	84	2	8,040	60
Lost Dog	10	84	24	8,880	14
Bears Ears	9	88	33	9,720	55
Sawmill Campground	9	89	12	9,960	17
Lost Creek TS * (Hayden RD)	14	86	27	9,000	17

* RD = Ranger District; TS = timber sale

** Data not available

++ Location called "Floyd Peak" in 1998

The combined total weekly beetle catch from the 10 locations on the Hahns Peak/Bears Ears Ranger District shows a strong peak in early July (Fig. 1). Fifty percent of the overall catch had been made by the week of July 9 and seventy-five percent had been caught by the week of July 23, two weeks later. This is consistent with prior descriptions of the attack period, which may be from May to early August depending upon the attainment of the flight temperature threshold (Schmid and Frye 1977).

These two locations were characterized by August catches (Fig. 2). The 3-Island Trail Head and Seedhouse locations had the second and third highest total catch, respectively, and are 2 – 3 miles apart at similar elevations within the Elk River corridor near the greatest concentration of windthrow from the Routt Divide Blowdown. In addition, all the other locations near or within the concentrated windthrow from the Routt Divide Blowdown also had late summer catches. These locations are Reed Creek, within 2 miles of Floyd Peak, Lost Dog, and Floyd Peak. While proximity to the Routt Divide Blowdown may be a factor, the results afford no clear conclusion at present.

EXTENT SURVEY

Spruce beetle infestation was found at 97 of the 110 sites surveyed, comprising 88% of the sites checked (Table 2). These sites are located across the spatial extent of blowdown, with the exception that few of the sites were within the Mt. Zirkel Wilderness (Figure 5). Spruce beetles were found in nearly every patch of blowdown inspected. Attempts were made using several methods to estimate the number of downed spruce per acre in windthrow patches, but the results were not satisfactory. The lack of uniformity in windthrown patches made it inappropriate to reasonably generalize any findings to represent unsampled areas.

The presence of spruce beetles varied greatly among trees inspected at a given site. Of an overall total of 811 blown down spruce trees, 392 (48%) had some level of spruce beetle infestation. The percentage of infested windthrow varied a great deal among sites.

Ips spp. beetles were found infesting windthrow in 487 of the 811 windthrown trees that were checked (60%). *Ips* beetles were present in a higher percentage of windthrow trees than were spruce beetles. This shows the potential for competition between these phloem-feeding bark beetles.

At 92 of the 110 locations (84%), the inner bark or phloem was classified as moist. Of the remaining 18 locations, nine had no data, six were classified as having almost dry phloem and three had phloem considered to be dry. Windthrow remained suitable habitat and was available for colonization by the 1999 spruce beetle generation.

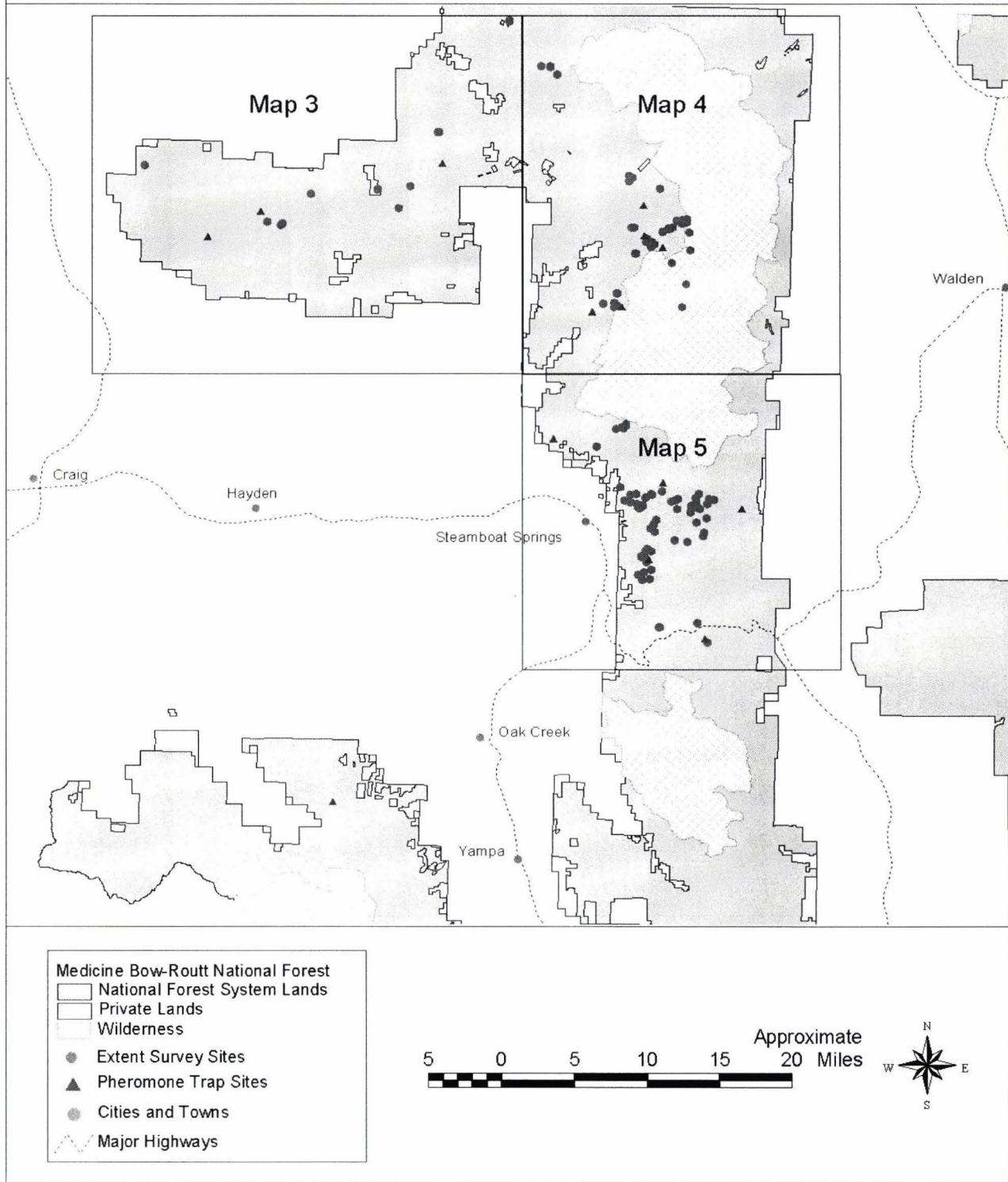
It was predicted in advance that a greater percentage of examined windthrow would be occupied in the 1999 survey, as compared with the 1998 survey. This would be the case because the 1999 generation of spruce beetles would have colonized the trees, in addition to the 1998 generation of spruce beetles that already colonized the blowdown last year. And beetles that completed their life cycle in one year starting in 1998 were expected to reenter the blowdown in 1999.

Table 2 displays a summary of extent survey data to detect spruce beetle infestation in windthrow on the Hahns Peak/Bears Ears Ranger District, Medicine Bow - Routt National Forest, Colorado, conducted from June through October 1999. Geographic areas are those from the current Forest Plan for the Routt National Forest.

Table 2. Extent Survey Data

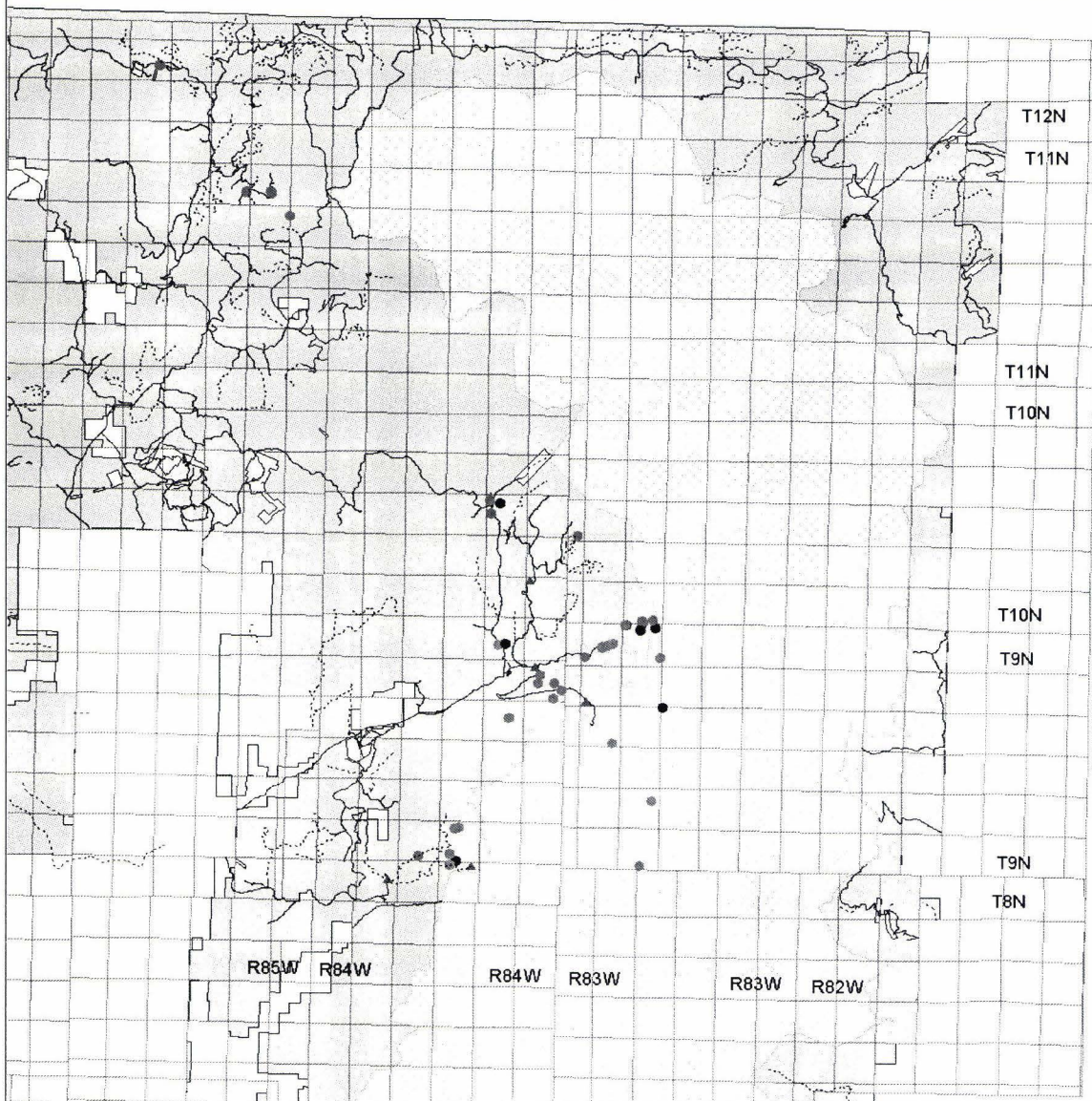
Geographic Area	Subarea	Windthrow Sites Surveyed	Windthrow Sites with Spruce Beetle
Middle Yampa	(except ski area)	63	55
Middle Yampa	Steamboat Ski area	14	14
Upper Elk	(except Wilderness)	33	28
Upper Elk	Mt. Zirkel Wilderness	5	4
Little Snake		6	6
Slater Creek		7	7
Elkhead Mountains	Bears Ears	1	1
	TOTAL	110	97

Location of 1999 Spruce Beetle Extent Surveys Medicine Bow-Routt National Forest



Map 2. Spruce Beetle Extent Survey Locations

1999 Spruce Beetle Extent Survey Sites Medicine Bow-Routt National Forest



- Extent Survey Sites**
- spruce beetles not found
 - spruce beetles found
 - ▲ pheromone trap sites
- Medicine Bow-Routt National Forest**
- National Forest System Lands
 - Private Lands
- Open Roads**
- Closed Roads**
- Township, Range, and Section Lines**

Approximate
1 0 1 2 3 4 5 Miles



Map 4. Spruce Beetle Extent Survey Locations – Northeastern Inset

Table 3 shows 14 spruce beetle (SB) extent survey locations from 1998 that were surveyed again in 1999. The locations are in blowdown on the Hahns Peak/Bears Ears Ranger District, Medicine Bow-Routt National Forests, Colorado.

Table 3. 1998 Extent Survey Locations

Survey Year	Township (North)	Range (West)	Section	Number of Trees Examined	Number of Trees with SB	Percent of Trees with SB	SB Pupae Present?	Live SB Adults Present?
1998	5	83	17	11	6	55%	N	Y
1999	5	83	17	3	3	100%	Y	Y
1998	6	84	1	10	2	20%	Y	Y
1999	6	84	1	4	4	100%	Y	N
1998	6	84	1	10	5	50%	Y	Y
1999	6	84	1	8	2	25%	Y	Y
1998	9	84	11	13	8	62%	N	Y
1999	9	84	11	5	4	80%	Y	Y
1998	10	83	4	32	11	34%	Y	Y
1999	10	83	4	20	7	35%	Y	N
1998	10	83	4	10	0	0%	N	N
1999	10	83	4	5	1	20%	Y	N
1998	10	83	4	10	0	0%	N	N
1999	10	83	4	6	1	17%	Y	N
1998	10	87	23	3	2	67%	Y	Y
1999	10	87	23	8	1	13%	Y	N
1998	10	83	34	10	0	0%	N	N
1999	10	83	34	5	4	80%	Y	N
1998	10	83	34	10	1	10%	Y	Y
1999	10	83	34	4	2	50%	Y	N
1998	11	85	2	11	3	27%	Y	Y
1999	11	85	2	4	4	100%	Y	Y
1998	11	85	3	3	3	100%	Y	Y
1999	11	85	3	4	4	100%	Y	Y
1998	11	86	33	2	1	50%	Y	N
1999	11	86	33	2	2	100%	Y	Y
1998	12	85	20	9	3	33%	Y	N
1999	12	85	20	4	4	100%	Y	Y

Table 4 shows Spruce beetle brood density per square foot of bark surface on 76 windthrown spruce at various locations on the Hahns Peak/Bears Ears Ranger District, Routt National Forest, Colorado, estimated from one 6 inch by 6 inch bark sample taken from the top, bottom, and lateral surface of each sampled tree

Table 4. Spruce Beetle Brood Density

Variable	Hwy 40	Buffalo Pass	Ski Area	Floyd Peak	Upper Elk	Bears Ears
Number of trees sampled (N)	12	9	18	11	21	5
% bark samples with SB present (3N total *)	61%	56%	54%	58%	57%	47%
Average brood density - TOP Surface	25.7	8.0	6.2	20.7	17.9	9.6
Standard deviation - Top	47.5	24.0	5.6	52.9	36.7	21.5
Average brood density - LATERAL Surface	22.7	50.2	33.6	53.1	36.0	61.6
Standard deviation - Lateral	38.7	72.7	50.4	34.5	47.0	63.8
Average brood density - BOTTOM Surface	31.3	84.9	116.0	45.1	61.9	18.4
Standard deviation - Bottom	27.3	63.6	137.7	59.0	64.0	32.9
Estimated average brood density per tree **	25.6	48.3	47.3	43.0	38.0	37.8
Standard deviation per tree	25.1	46.5	51.1	18.0	30.6	40.3
Standard error of the average ***	7.2	15.5	12.1	5.4	6.7	18.0

* Three 6 X 6 inch bark samples were taken from each tree, giving a total of 3N samples

** Estimated by averaging the brood sample results per tree across the three surfaces and doubling the sample result from the lateral surface, calculated as follows: $[(\Sigma \text{ brood TOP}) + (\Sigma \text{ brood BOTTOM}) + 2 (\Sigma \text{ brood LATERAL})] / 4$

Summarizing blowdown-outbreak relationships from his work with these seven populations, Schmid (1981) presents spruce beetle population and windthrow characteristics that signify the capability to produce significant numbers of infested, standing trees, as follows:

- Attack densities ≥ 1 per sq. ft. on the top or ≥ 5 per sq. ft. on the bottom surface
- 100 or more infested trees in the windthrow patch
- Adult beetle densities ≥ 45 per sq. ft in August-September samples on the bottom surface

Of these three characteristics, attack densities were not measured in 1999. This is because attack densities are difficult to count accurately after trees absorb attacks from two different generations of beetles.

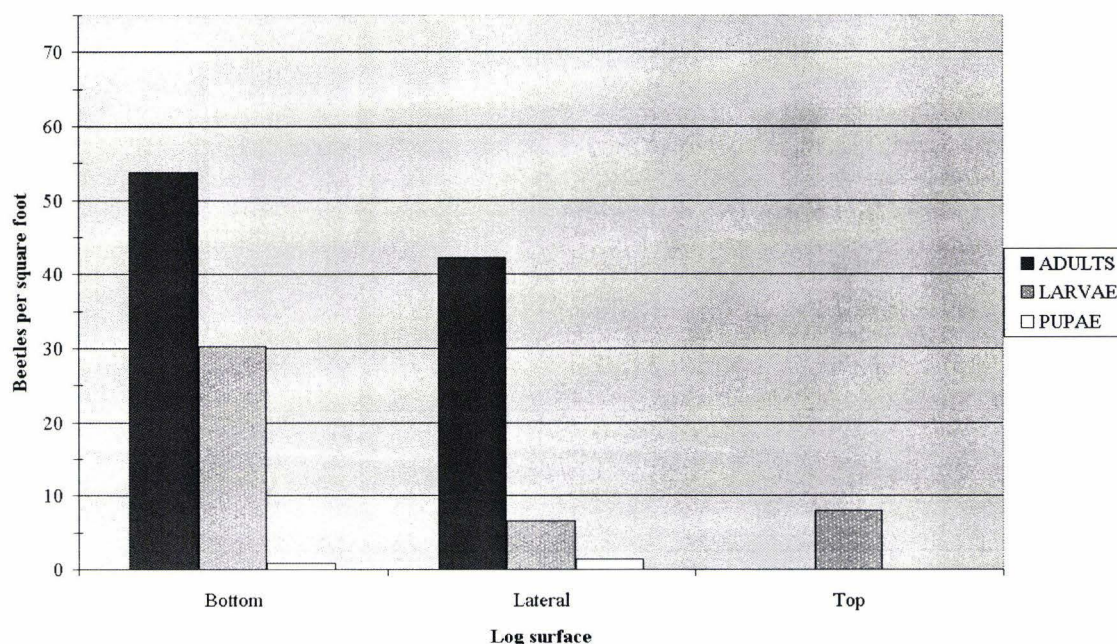
The number of infested trees in a patch is also not an especially applicable characteristic. One hundred or more windthrown trees can be found in hundreds of patches on the Hahns Peak/Bears Ears Ranger District and many locations elsewhere in Colorado and Wyoming. The extent survey results indicate that most of these patches are infested by spruce beetles. Because of the extensive blowdown that occurring from 1997 to the present, many locations clearly meet this characteristic of 100 or more infested trees per windthrow patch.

Therefore, adult beetle densities equal to or greater than 45 per square foot becomes the “standard” by which to assess if local spruce beetle populations within windthrown patches possess characteristics capable of producing significant numbers of infested, standing green trees.

Brood sampling results show that this “standard” was met at two or possibly three locations in 1999 (Figures 5-7).

Figure 4. Brood Density by Log Surface and Life Stage, Buffalo Pass

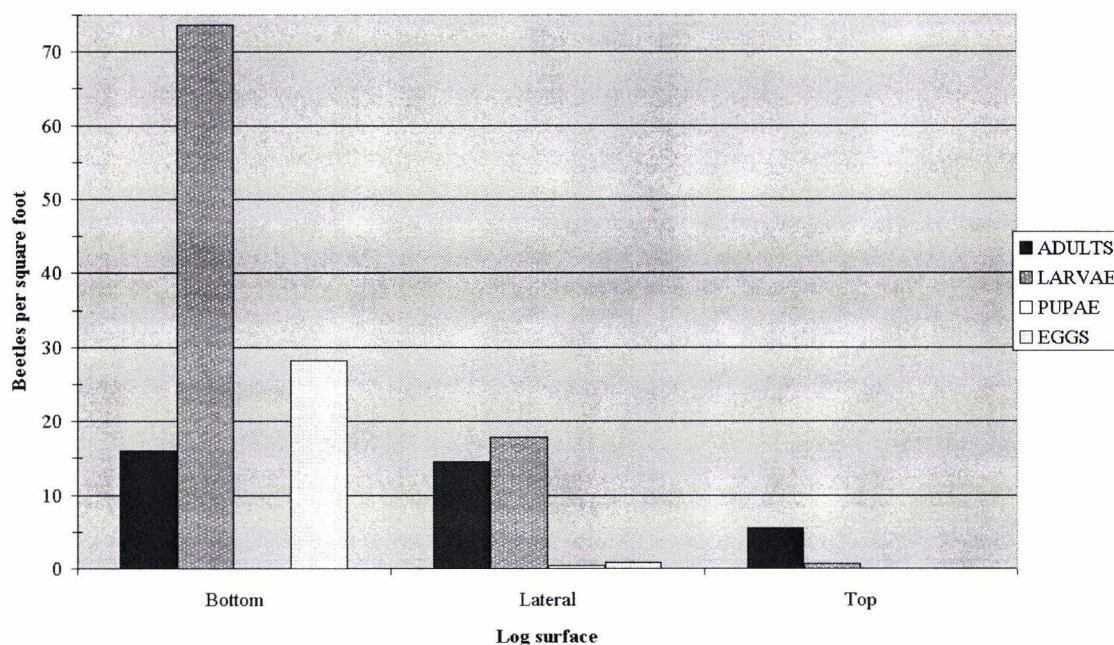
Figure 4. Sample density of spruce beetles in 9 windthrown trees in late summer 1999 by log surface and life stage, Buffalo Pass, Routt National Forest, Colorado.



Buffalo Pass was the location with the highest density of adult beetles on the bottom surface of windthrow (Figure 4). Surprisingly, significant numbers of spruce beetle adults were also found on the lateral sample surface, although this surface was generally unshaded in the blowdown patches at the Buffalo Pass location. This means that the spruce beetle population has outcompeted *Ips* beetles for the inner bark on the

Figure 6. Brood Density by Log Surface and Life Stage, Steamboat Ski Area

Figure 6. Sample density of spruce beetles in 18 windthrown trees in late summer by log surface and life stage, Steamboat Ski Area, Colorado.



Adults were the predominant life stage of spruce beetle brood in the late summer at the following locations: Highway 40, Buffalo Pass, Upper Elk, and the Bears Ears. These locations become top priority sites for 2000 surveillance survey, because the beetle adults are expected to exit the windthrow in the early summer of 2000 and may attack green trees. All other locations were dominated by the larval life stage. While these sites are of concern, the concern is not as pressing because most of the beetle brood is not expected to mature and exit as adults until the summer of 2001.

The Steamboat Springs Ski Area is a location where the larval stage was the most common and where spruce beetles were present in dense populations within windthrow (Figure 6). Although mortality due to natural enemies, competition, weather, and other causes will lower the beetle density during 2000, it is expected that this dense population will still be sizeable when emerging in 2001. The 1999 beetle generation at the Ski Area location may be larger than the 1998 generation, though the level of future brood mortality is unknown.

Spruce beetle eggs were found in brood samples taken August 31, 1999. Five trees at the Steamboat Springs Ski Area had eggs, four from bottom samples and one from a lateral sample (Figure 6;). A total of 123 eggs were counted on the ski area from these five trees. These eggs seemed to be fresh, turgid, and viable, although they were not collected. That same day, one tree on Floyd Peak in the Upper Elk location had 19 eggs in one brood sample taken from the lateral surface. Spruce beetles were captured in pheromone traps in August of 1999. These eggs were laid by the later flying beetles, which were clearly attacking trees and establishing new broods late in the summer.

EMERGENCE CAGE AND "ONE YEAR" BEETLES

The emergence cage on Buffalo Pass collected 12 adult spruce beetles that emerged from the windthrown tree under the caged portion during the summer of 1999. This substantiates the observations from 1998 that a small percentage of the spruce beetle population within the windthrow completed their development in one year and emerged. It was unfortunate that more cages were not similarly deployed.

As emerging adults began to disperse, seeking suitable host material, they responded to the chemical lure in the traps. The increase in pheromone trap catch may indicate that the blowdown was becoming less suitable for spruce beetle populations. A reduction in suitability may be partly due to the increasing degree of infestation, because a second generation of spruce beetles entered the blowdown in 1999. Infestation by *Ips* spp. was found at a higher percentage (60%) than infestation by spruce beetle (48%) during the extent survey, so competition may be a factor. Although important to windthrow suitability, drying probably played a minor role in 1999, because windthrow at nearly all of the extent survey locations was classified as "moist." It is also likely that the number of flying spruce beetles was greater in 1999, as compared with 1998.

That spruce beetles can disperse long distances (Schmid and Frye 1977) is illustrated by the result from the Mad Creek trap location, where 3 beetles were captured in 1999. This location was chosen initially from the office in 1998 to fill a perceived "map gap" on the north to south extent of the Routt Divide Blowdown along which traps were to be deployed. The Mad Creek trap location is about three miles to the east from any known blowdown and is several miles from the nearest spruce stand. It was decided to maintain this trap location in 1998 and 1999 to determine if spruce beetles dispersing from the blowdown could be captured at a distance. Having shown that spruce beetles can be caught far from any known source of breeding material, it is likely that this location will be dropped in 2000.

MOST BLOWDOWN PATCHES ARE INFESTED

Windthrow was infested by spruce beetles at 88% of the surveyed locations in 1999. This result is virtually the same as was obtained in 1998, when 86% of 35 surveyed locations were infested (Schaupp et al. 1999). The potential problem presented by spruce beetle inhabiting windthrow exists in many places.

POPULATION INCREASES IN BLOWDOWN

Casual observations, survey and sampling results indicated that spruce beetle densities in windthrow from the Routt Divide Blowdown were low in 1998 (Schaupp et al. 1999). Because 1998 was the first year that the windthrow could be infested, it was expected that additional colonization of these windthrown trees would occur in 1999.

While the percentage of infested locations remained about the same, individual trees have more of their bark surface area occupied by spruce beetles. Many more brood samples contained spruce beetles. In 1999, the percent of positive brood samples ranged from 47 – 61% (Table 3); in 1998, the percent of positive samples was 20 and 40% at Buffalo Pass and Walton Creek, respectively (Table 3 in Schaupp et al. 1999). The percentage of infested trees increased at most of the 14 sites surveyed in both 1998 and 1999 (Table 3). In this way, overlapping generations of spruce beetles occupy and increase within the blowdown.

Spruce beetle brood densities were greater in 1999, as compared with 1998. Brood sampling results at the two locations that were sampled both in 1998 and 1999 also illustrate this finding. In 1998, at Buffalo Pass and the Walton Creek Blowdown (Schaupp et al. 1999), the whole tree density of brood was 14.5 and 4.3 beetles per square foot, respectively. In 1999, the brood density in a different set of trees at the same general locations was 48.3 for Buffalo Pass and 25.6 for Highway 40, including trees from the Walton Creek Blowdown. This represents a 3 to 6 fold increase in the density of spruce beetles within the windthrow.

Evidence from general observations, extent surveys, and brood sampling support the prediction that more of the windthrow would be occupied by spruce beetles and that beetle densities within the windthrow would increase 1999, as compared with 1998. Spruce beetles were more easily found in windthrow in 1999 because more of the available area was occupied than in 1998. The 1999 spruce beetle generation and "one year" beetles added their numbers to the 1998 spruce beetle generation that had entered the blowdown during 1998.

Adult brood densities in at least three locations, Buffalo Pass, Upper Elk, and Bears Ears, were high enough to put these locations on the list of potential "hot spots." Whole tree densities or large larval populations indicated a potentially severe tree-killing episode was possible at all other brood sampling locations except the Highway 40 corridor.

CHANGE IN ENDEMIC STATUS EXPECTED

The wind events, which caused the Routt Divide Blowdown and other windthrow, have resulted in abundant spruce beetle breeding material throughout the spruce-fir forest vegetation type on the Hahns Peak/Bears Ears Ranger District of the Medicine Bow - Routt National Forest and surrounding areas. During the 1998 field season, spruce beetle was just beginning to utilize the downed spruce trees and sparse populations could be found in almost any patch of blowdown. There were also a small number of spruce beetles on a one year life cycle that either reinfested downed trees or attacked standing weakened trees in the summer of 1999. In 1999, infestations intensified and expanded within the windthrow. The current condition of many of the spruce stands on the Hahns Peak/Bears Ears Ranger District and surrounding areas, with continued windthrow and standing damaged trees, will create more potential host material for beetle populations over several years.

Spruce beetles in windthrown trees are afforded some protection from mortality agents. Snow thermally protects developing beetles from lethal temperatures and snow covered surfaces are protected from predation. The weather conditions for the '99 - '00 winter were not severe enough to cause significant mortality to overwintering spruce beetle populations. Therefore, we can expect a large percentage of the spruce beetle population currently in windthrown trees to survive and continue to develop.

As suitable habitat is exhausted within the windthrow, beetles are likely to emerge and attack standing spruce trees. Based on past experience with significant windthrow events and early reports from the field in 2000, that has begun to happen. The location(s), extent, and duration of the predicted spruce beetle epidemic(s) is not known. Hotspots have been identified, some have been treated, and others will be located by monitoring in 2000.

The immensity of the Routt Divide Blowdown, the wide variety of blowdown patch sizes, and the different conditions in these patches present the spruce beetle with a very significant opportunity. With a susceptible spruce/fir forest and favorable weather, scattered incipient epidemics in standing trees should become evident. These infestations could intensify, spread, and eventually coalesce to create landscape level disturbances, causing abundant mortality of the mature spruce component, e.g. the Flat Tops and surrounding outbreaks of the 1940s to early 1950s. Management efforts can locally mitigate spruce beetle impacts to varying degrees, but stopping a landscape-level spruce beetle epidemic once it has begun is almost impossible. However, incipient epidemics can be controlled if proper suppression and prevention activities are initiated before these epidemics reach landscape proportions.

RECOMMENDATIONS AND ACTIONS TAKEN

The following recommendations were detailed in the first biological evaluation of the spruce beetle situation on the Hahns Peak/Bears Ears Ranger District (Schaupp et al. 1999). Using the first sentence of each recommendation as a title, we will summarize actions taken thus far and present suggestions for future activity.

1. Develop a realistic "worst-case" scenario.

- This has been done. Stand data from inventory files and interpreted aerial photography has been analyzed, resulting in a classification with maps showing the relative probability of infestation by spruce beetle on a stand basis. This classification has been combined with assumptions made by Forest Health Management staff, based on published literature and professional judgment, as to what such a landscape level spruce beetle epidemic scenario might entail. While not a prediction of the most likely outcome, these assumptions allow planning for the most extreme case scenario. The occurrence of anything less than the extreme case scenario should therefore be encompassed by such planning efforts.

LITERATURE CITED

- Frye, R.H., J.M. Schmid, C.K. Lister, and P.E. Buffam. 1977. Post-attack injection of Silvisar 510 (cacodylic acid) in beetle infested spruce trees. *The Canadian Entomologist* 109: 1221-1225.
- Furniss, R.L. and V.M. Carolin. 1977. Western Forest Insects. *USDA Forest Service Miscellaneous Publication No. 1339*, 654 pgs. USDA Forest Service, Washington, DC.
- Holsten, E.H., R.W. Thier, A.S. Munson, and K.E. Gibson. 1999. The spruce beetle. *USDA Forest Service, Forest Insect and Disease Leaflet 127* (revised 11/1999), 12 pgs. USDA Forest Service, Washington, DC.
- Knight, F.B. 1960. Measurement of Engelmann spruce beetle populations. *Ecology* 41: 249-252.
- Safranyik, L. and D.A. Linton. 1999. Spruce beetle (Coleoptera: Scolytidae) survival in stumps and windfall. *The Canadian Entomologist* 131: 107-113.
- Schaupp, W.C., Jr., M. Frank, and S. Johnson. 1999. Evaluation of the spruce beetle in 1998 within the Routt divide blowdown of October 1997, on the Hahns Peak and Bears Ears Ranger Districts, Routt National Forest, Colorado. *Biological Evaluation R2-99-08*, 15 pgs. USDA Forest Service, Rocky Mountain Region, Renewable Resources, Lakewood, CO.
- Schmid, J.M. 1981. Spruce beetles in blowdown. *USDA Forest Service Research Note RM-411*, 6 pgs. Rocky Mountain Forest and Range Experiment Station, Ft. Collins, CO.
- Schmid, J.M. and R.H. Frye. 1976. Stand ratings for spruce beetles. *USDA Forest Service Research Note RM-309*, 4 pgs. Rocky Mountain Forest and Range Experiment Station., Ft. Collins, CO.
- Schmid, J.M. and R.H. Frye. 1977. Spruce Beetle in the Rockies. *USDA Forest Service General Technical Report RM-49*, 38 pgs. Rocky Mountain Forest and Range Experiment Station, Ft. Collins, CO.
- Schmid, J.M. and S.A. Mata. 1996. Natural variability of specific forest insect populations and their associated effects in Colorado. *USDA Forest Service General Technical Report RM-GTR-275*, 14 pgs. Rocky Mountain Forest and Range Experiment Station., Ft. Collins, CO.
- Veblen, T.T., K.S. Hadley, E.M. Nel, T. Kitzberger, M. Reid, and R. Villalba. 1994. Disturbance regime and disturbance interactions in a Rocky Mountain subalpine forest. *Journal of Ecology* 82: 125-135.

management specialists. In the event of an outbreak, a majority of spruce in the larger diameter classes (> 12 inches DBH) will be killed.

2. Medium. Susceptibility to attack and damage is a concern in attaining management objectives, but is definitely less than in high rated stands. The degree of concern will depend upon management objectives for the area and how a potential spruce beetle outbreak might affect them.
3. Low. Susceptibility to attack and damage by spruce beetle is not a concern.

An important consideration in any silvicultural treatment is wounding of residual trees. Great care must be exercised in any mechanical entry to avoid wounding. Especially with subalpine fir and, to a lesser degree, spruce species, wounds provide entry courts for decay and root disease fungi. Not only can these agents lead to tree mortality, it is likely that there is an interaction between spruce beetle and infected trees, rendering them more susceptible to beetle attack.

Cutting methods in susceptible stands

Once a spruce beetle infestation reaches epidemic proportions in susceptible stands, chances for control are greatly reduced. Hence vegetation management strategies aimed at preventing the accumulation of numerous high-risk stands and other high-risk beetle situations are the preferred management approach.

Intermediate Cutting Methods

A. Sanitation/Salvage. During an outbreak, beetle infested, dead, and highly vulnerable large diameter spruce is removed in an effort to maximize utilization of attacked material. Salvage of significant blowdown material within 1 to 2 years, particularly when it occurs in and adjacent to highly susceptible stands, is recommended where it meets overall management objectives.

B. Presalvage. With the imminent threat of an outbreak, large diameter, slow growing spruce is removed from highly susceptible stands. Presalvage is the removal of merchantable trees in anticipation of losses likely to occur before definitive regeneration cuts (Smith 1986). In some situations, presalvage may achieve the same results as a shelterwood cut.

C. Precommercial thinning. Thinning young stands to regulate stocking and species composition may be appropriate when commensurate with other stand objectives.

D. Commercial thinning. Thinning at 20 or 30 year intervals will improve stand vigor. While thinned stands have higher average diameter, benefits from improved vigor likely outweigh risks associated with having larger diameter trees. Thinning pine stands susceptible to mountain pine beetle indicates that the habitat modification provided by thinning is an important contributor to reduced stand susceptibility. Spacing between trees is the critical factor in this, rather than just reducing tree density. It is likely that habitat modification in thinned spruce stands would play a similar role of reducing stand susceptibility to spruce beetle. However, windthrow is a significant concern when increasing inter-tree spacing. A long term goal of thinning more appropriate to spruce/fir stands may be to create a mosaic of age classes rather than trying to maintain a single age class.

Even-aged Regeneration Cutting Methods

A. Clearcutting. This method effectively eliminates bark beetle risk on treated acres for a considerable period of time. However, if faced with large acreages of unmanaged, highly susceptible stands, clearcut regeneration techniques will require decades to achieve a level of management where beetle risk is diminished. Where locations have a mix of low, medium, and high-risk stands, clearcutting the high risk stands over one or two decades may diminish the overall beetle risk. Regeneration needs will significantly affect the location and degree to which this method is employed.

B. Shelterwood. This method has advantages over clearcutting when an objective is to reduce beetle susceptibility within a location in a minimum of time. For a given sale quantity, shelterwood cuts would require treatment of more acres than clearcutting. Shelterwood prescriptions should provide opportunities to remove

and Frye 1977). Nagel et al. (1957) recommends one trap tree for every four to five infested standing trees. Schmid and Frye (1977) include a table for more precise estimates of the number of trap trees to be felled based on the current infestation level.

Sanitation of infested trees

This treatment strategy does not differ in principle from silvicultural treatments where trees currently infested by spruce beetle are removed or treated to kill the beetles within them. In practice, this treatment differs from silvicultural treatments in that fewer trees are removed and mechanical means may or may not be used. Prompt identification and treatment of infested trees before the inhabiting beetles emerge will remove a local source of contagion. It can afford a degree of protection to nearby susceptible trees and stands. Consideration must be given to the relative susceptibility of the adjoining landscape and the local "beetle pressure." Where both are at a high level, sanitation of a few infested individual trees is not likely to have a positive benefit due to immigration of beetles and because the number of trees removed may not alter susceptible stand conditions.

CHEMICAL

Lethal Trap Tree Method

Lethal trap trees, a modification of the traditional trap tree method, are another effective option to attract, hold and eliminate beetles from the forest (Frye and Wygant 1971, Buffam 1971, Buffam et al. 1973, Lister et al. 1976). Lethal trap trees eliminate the need to remove infested material from the forest and can be especially useful in areas where removal of material is prohibitive. Prior to felling, the trap tree is injected with a silvicide, making it a lethal trap tree. Currently, no silvicides are registered for use in the United States.

A variation of the lethal trap tree method is to apply an insecticide to the felled trees so that attacking beetles are killed as they attempt to bore into the treated tree. Currently, several insecticides are registered and available for this use in the United States.

Insecticides preventing infestation

Insecticides can be applied to the boles of uninfested trees to kill attacking beetles and protect high value trees. Application of these insecticides will not kill larvae or adults already present in the phloem. These insecticides work directly on the attacking adults attempting to bore into the tree and therefore need to be applied prior to the tree being attacked by spruce beetles. Only insecticides labeled for this use can be applied.

Pheromones

Pheromones, or message bearing chemicals, are emitted by the spruce beetle and serve to coordinate and regulate their attack behavior. Synthetic versions of these chemicals are available that either attract or repel spruce beetles. Synthetic pheromone production and pheromone dissemination methods need to be improved to take full advantage of pheromone technology. In addition, variation in results of operational synthetic pheromone use indicate that we do not fully understand regional variations in the chemical components of spruce beetle pheromones and the role(s) played by host volatiles. A summary discussion of operational and potential spruce beetle pheromone uses with literature citations was provided by Stilen et al. (1997). Operational uses of spruce beetle pheromones at present include trap out and attack disruption. However, results are inconsistent.

The trap out tactic uses attractant pheromones to lure spruce beetles into traps or trap trees and thereby reduce beetle populations to a more acceptable level. This would work best in isolated, lower level beetle populations where immigration would not erase the impact of trapping. Treatment trials using this have shown that the synthetic attractant pheromones do not compete well with natural attractant pheromones and may have varying attractiveness, as currently formulated, in every region of the spruce beetle range. However, the trap-out tactic has been successful on isolated populations in Utah as part of an integrated strategy employing several tactics (Bentz and Munson 2000).

In most instances, we need to know a little bit about a lot of places and in a few instances, we need to know a lot about a few places --- this is a balancing act, choosing which type of information over what area is needed and using the best methods to obtain the needed information. The Forest Health Management group has learned that sufficiently accurate information and predictions can be made by following established protocols and by using sampling plans that strike a balance between these conflicting needs. The purpose of the evaluation is to give the land manager the best possible information covering the largest possible area as soon as possible. This document provides necessary information, in an evaluation rather than as a research study, to serve as a basis for decisions.

METHODS

Additional details and background information regarding methods are available in the prior biological evaluation, R2-99-08 (Schaupp et al. 1999).

AERIAL SURVEY

Aerial surveys were conducted from fixed wing, single engine aircraft flying at about 1,500 feet above the ground at approximately 100 miles per hour. Missions were flown during the "biological window" for bark beetles, the time of year that conifers fading from bark beetle colonization can best be detected. When the observer(s) detected recent tree mortality, the number of dead trees and probable cause(s) of death were coded and the affected area sketched onto 1:100,000 scale US Geological Survey 30 X 60 minute maps. It should be noted that the foliage on spruce killed by spruce beetle will fade during the two summers that follow the summer of initial beetle infestation. Similarly, windthrow areas were detected and estimated as polygons sketched onto the maps.

Erik Johnson (Aerial Survey Program Manager, Forest Health Management), assisted by Willis C. Schaupp, Jr., conducted an aerial survey of the Sierra Madre and Medicine Bow mountain ranges, including the Medicine Bow National Forest and environs, in mid July 1999. They also surveyed the entire Routt National Forest and environs, including the Gore and Park Range(s), the Medicine Bow Mountains, and the northern portion of the Flat Tops, on July 17-23, 1999. Aerial survey provides general detection information quickly over an extensive area at low cost. It provides trend and approximate location information, which is intended to induce site visits on the ground in areas of concern. Acquisition of aerial survey information is described in Appendix 2.

PHEROMONE TRAPPING

The spruce beetle attack period was monitored using 16-funnel Lindgren traps baited with a chemical lure, a commercially available two-component synthetic version of the spruce beetle aggregation pheromone. Deployment was accomplished according to the technical bulletins and advice provided by the manufacturer of both the traps and chemical attractants.

The number of pheromone trapping locations was increased from seven in 1998 to thirteen in 1999. This increase was in response to the recommendation that areas of timber harvest or salvage be monitored with traps (Schaupp et al. 1999) and to provide greater coverage of the blowdown areas.

Two traps were deployed at each of 13 locations (Table 1). Traps were deployed during May and June, snow and mud permitting. The traps were checked weekly until mid-August, thereafter checked every two weeks, and checked for the last time during the week of September 9, 1999. Trap capture data establish the presence of attacking spruce beetles in an area and identify the timing of such attacks. It may also be possible to draw tentative conclusions about population trends for a given location by comparing data from consecutive years.

measured and the diameter of surrounding, standing trees was obtained from the Forest's timber stand inventory database (Rocky Mountain Resource Information System or RMRIS).

EMERGENCE CAGE

At five locations in 1998, it was determined that a small percentage of the spruce beetle population developing within windthrow had reached the adult stage before their first winter (Schaupp et al. 1999). It was concluded that these beetles were going to complete their life cycle in one year instead of the more usual two years that is required in the central Rocky Mountains (Schmid and Frye 1977). In an attempt to validate this conclusion, an emergence cage was stapled onto the lateral and bottom surfaces of the lower stem of a windthrown tree on Buffalo Pass in September 1998. If spruce beetles under the bark actually matured in one year, they would be expected to emerge during the summer of 1999 and be caught in the collection jar. The emergence cage on Buffalo Pass was checked in October 1999, during brood sampling.

RESULTS AND CONCLUSIONS

AERIAL SURVEY

Four small polygons with an estimated total of 11 trees recently killed by spruce beetle were detected on the Hahns Peak/Bears Ears Ranger District during the 1999 aerial survey. Three of these polygons (nine trees total) were located on the west side of the Elk River near the confluence with Mad Creek about 7 miles northwest of Steamboat Springs. This riparian area showed minor activity attributed to spruce beetle (Schaupp et al. 1999). The fourth polygon (two trees) was located near the confluence of the Middle Fork of Whiskey Creek and King Solomon Creek approximately eight miles north of Columbine. None of these polygons have been verified by ground visits as of July 2000. All of these polygons are three or more miles distant from the main portions of the Routt Divide Blowdown.

No spruce beetle activity was detected in standing trees on the surveyed portion of the Medicine Bow National Forest. On the remainder of the Routt National Forest, only four other polygons were detected in 1999, all in the northern Flat Tops area, with a combined total of 19 trees. These small areas of spruce beetle activity are located in Township 3 North and Ranges 88, 89, and 90 West.

The 1999 aerial survey results mean that most of the spruce beetle populations either remain within blowdown or have spent less than one year inside standing, green trees, which have yet to fade.

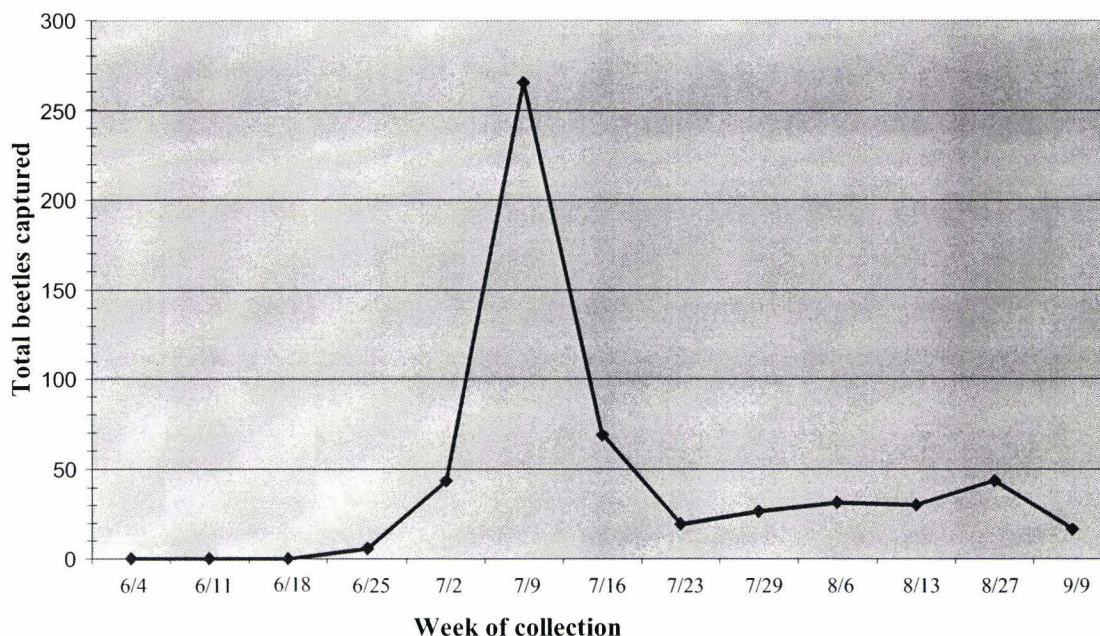
PHEROMONE TRAPPING

The first spruce beetle captures were made during the week of June 25 (Figure 3). The number of spruce beetles captured varied greatly by location (Table 1). Traps at 12 of 13 locations caught a total of 548 spruce beetles. Although spruce beetles were captured in the 13th trap at the Yampa Ranger District location, the collected beetles were misplaced before they were counted and the data is therefore not available. Traps caught no spruce beetles at only one location, the Sawmill timber sale location on the Parks Range District. The Floyd Peak trap location accounted for 55% of all the spruce beetles captured. With a total capture of 304, the traps at Floyd Peak caught five times more spruce beetles than traps with the second highest total, the Seedhouse location.

Figure 3 shows the combined weekly spruce beetle captures in pheromone traps placed two per location at 9 locations on the Hahns Peak/Bears Ears Ranger District, Medicine Bow – Routt National Forests, Colorado, 1999.

Figure 1. Weekly Spruce Beetle Captures 1999

Figure 1. Combined weekly spruce beetle captures in pheromone traps placed two per location at 9 locations on the Hahns Peak/Bears Ears Ranger District, Routt National Forest, Colorado, in 1999.

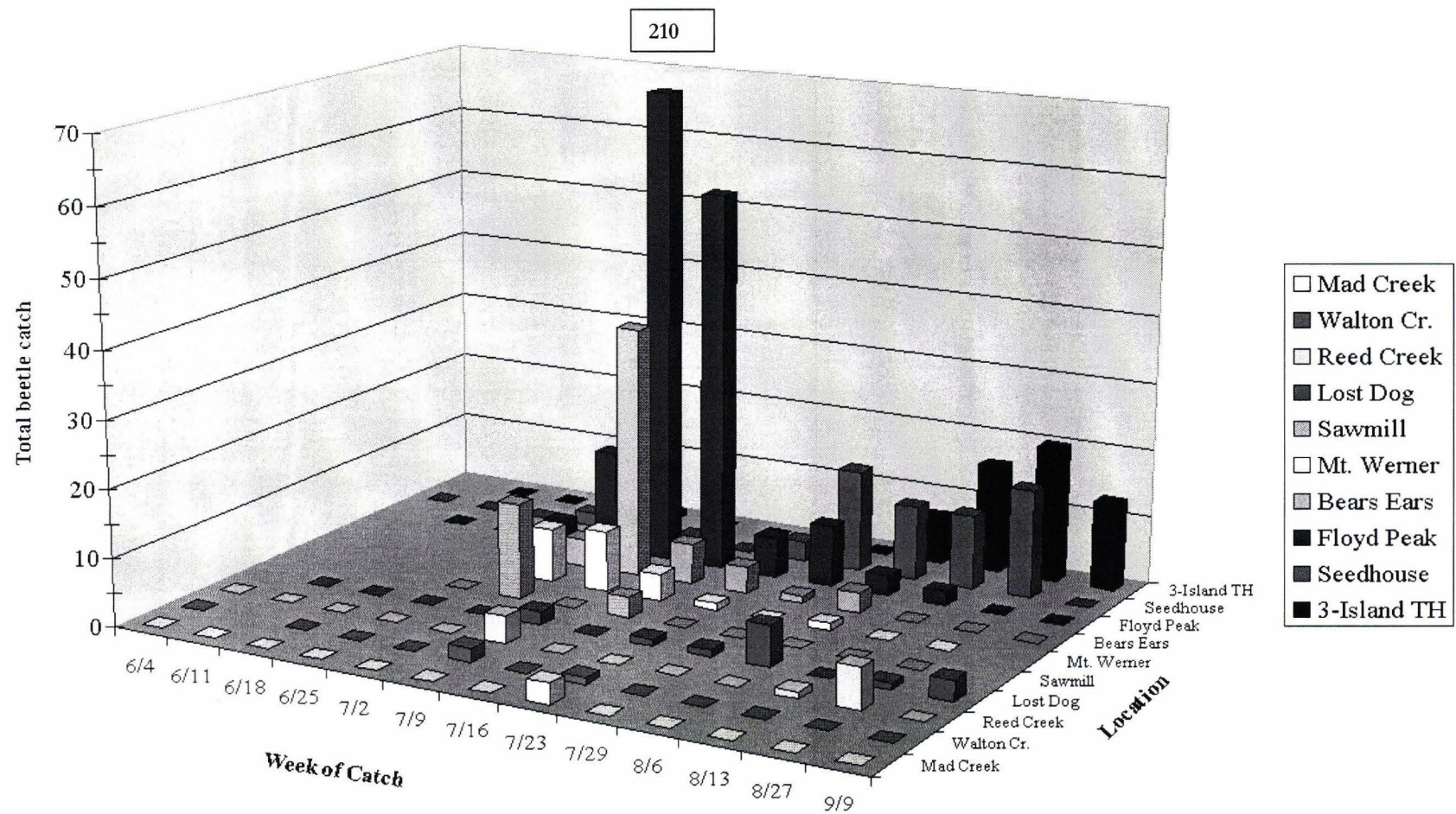


Surprisingly, twenty five percent of the combined total weekly beetle catch was made in August and early September. If trapping had not been discontinued in early September, the traps may have continued to catch spruce beetles. Beetles were caught over a longer time period than the six to eight week time span that was expected. The captured beetles could be attacking adults seeking to start a brood, parent adults that had reemerged to attack again and start another brood, or recently matured adults seeking hibernation sites for the winter. There was no sharp decline in trap catch at the end of the trapping period (Fig. 1), as would be expected from an attack period with one discrete peak. Flight may have peaked in different locations at different times. Something else is happening late in the summer that results in catching spruce beetles attracted to aggregation pheromone. Ground searches for newly attacked trees conducted in late summer may be completed before all spruce beetle attacks have occurred.

Combining weekly catches from the 10 trapping locations on the Hahns Peak/Bears Ears Ranger District masks a lot of variation between locations (Fig. 2). In addition, small trap catches in some cases make it difficult to interpret the results. The sharpness of the peak in beetle catch displayed in Figure 3 is mostly due to the Floyd Peak catch, which was by far the largest (Table 1). The peak trap catch of 210 beetles at Floyd Peak during the week of July 9 comprises 40% of the entire catch at all 10 locations. Most of the locations had peak trap catches at different times during July, somewhat similar to Floyd Peak, despite differences in elevation (Table 1). This includes the Bears Ears and Sawmill locations, both in the Elkhead Mountains, and Mt. Warner, within the Steamboat Springs Ski Area (Figure 2). However, peak catch at the 3-Island Trail Head and Seedhouse locations occurred during the week of August 27, much later than at other locations.

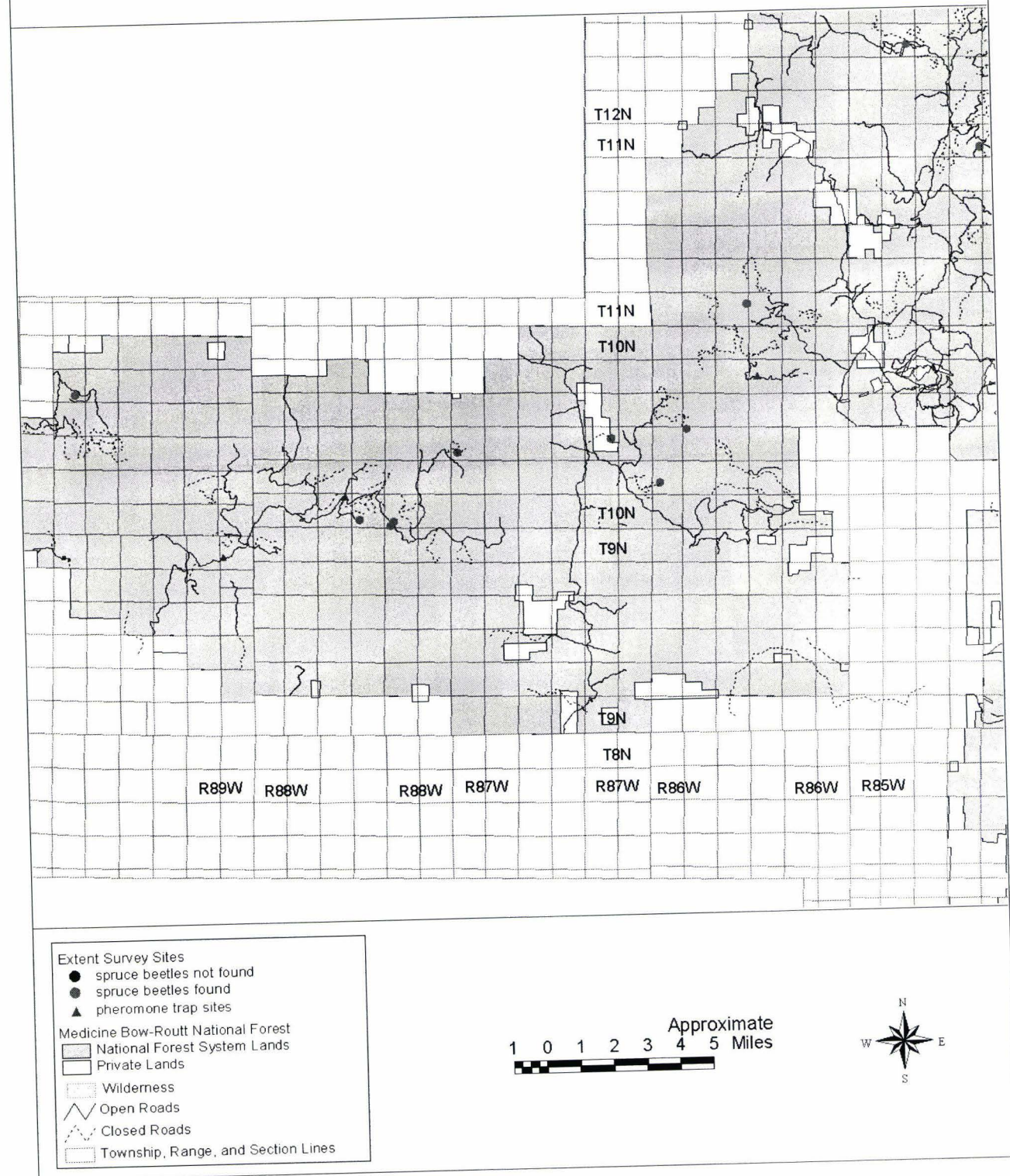
Figure 2. Spruce Beetle Captures - Lindgren Trap

Figure 2. Combined weekly spruce beetle catch in Lindgren pheromone traps placed two per location at 10 locations on the Hahns Peak/Bears Ears Ranger District, Routt National Forest, Colorado, in 1999.

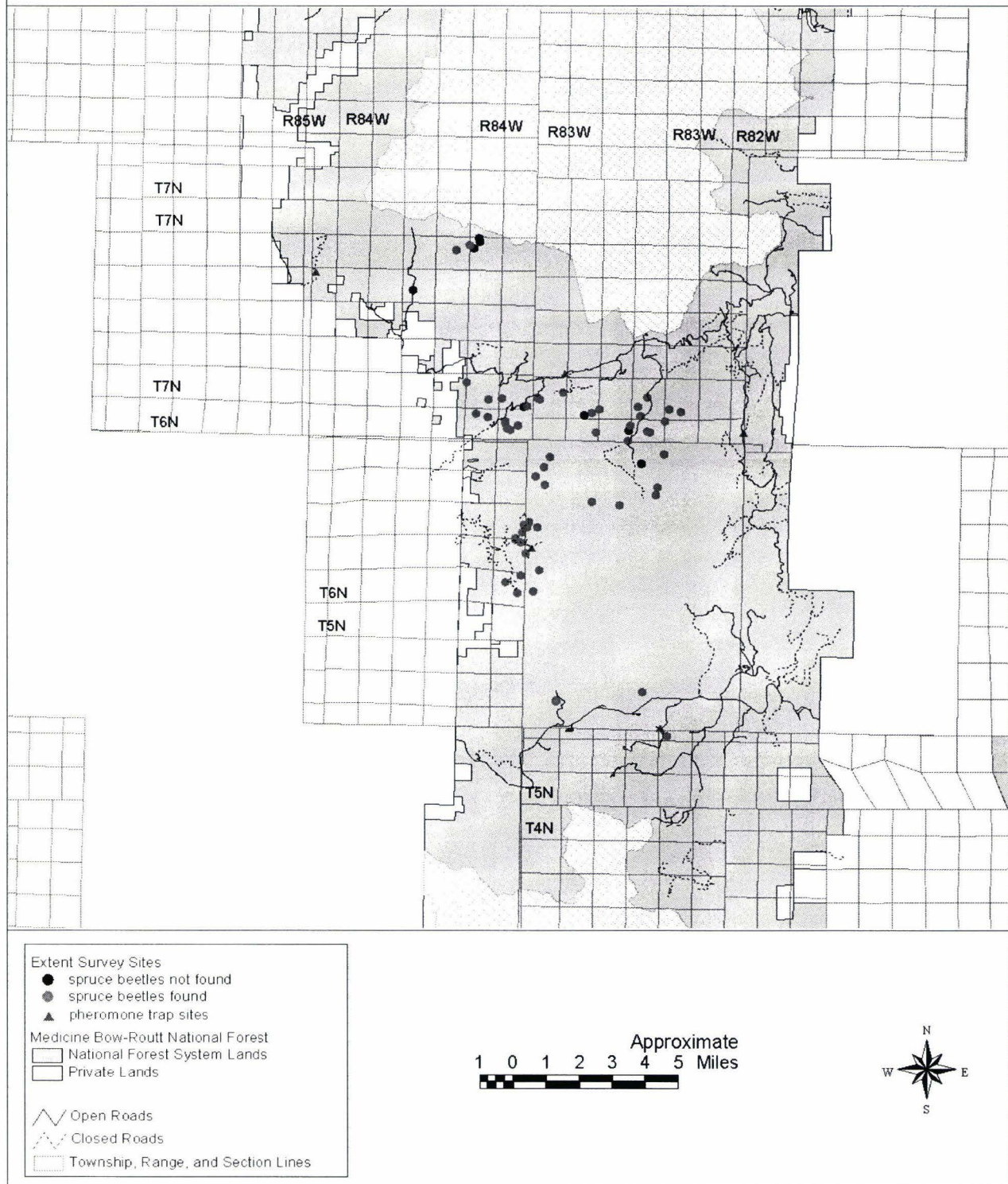


During the 1998 extent survey and general reconnaissance activities, spruce beetle pupae and "callow" or new adults were found within windthrow from the Routt Divide Blowdown. This finding indicated that a portion of the spruce beetle population may have completed its life cycle in one year (Schaupp et al. 1999). Due to the difficulty of distinguishing new from parent adult beetles, however, and the fact that several generations of spruce beetles coexisted within the blowdown in 1999, no additional observations of this nature could be made reliably during the extent survey. Results from an emergence cage, described hereafter, have added to the evidence supporting the conclusion that a small portion of the spruce beetle population in 1998 completed their life cycle in one year.

1999 Spruce Beetle Extent Survey Sites Medicine Bow-Routt National Forest



1999 Spruce Beetle Extent Survey Sites Medicine Bow-Routt National Forest



Map 5. Spruce Beetle Extent Survey Locations – Southern Inset

The percentage of windthrown trees infested by spruce beetle increased at extent survey locations that were sampled in both 1998 and 1999 (Table 3). Of the 14 locations, the infested percentages changed as follows: increased at 10 locations; remained the same at 2 locations, including one that stayed at 100%; and decreased at 2 locations.

BROOD SAMPLING

Spruce beetle brood density within windthrow was highly variable both among the three sample surfaces on the windthrown tree stem and among trees, as indicated by the large standard deviations associated with each of the average values in Table 4. These two sources of variation, surfaces and trees, were identified as important sources of variation in prior reports and discussions (Schmid 1981) and our results agree.

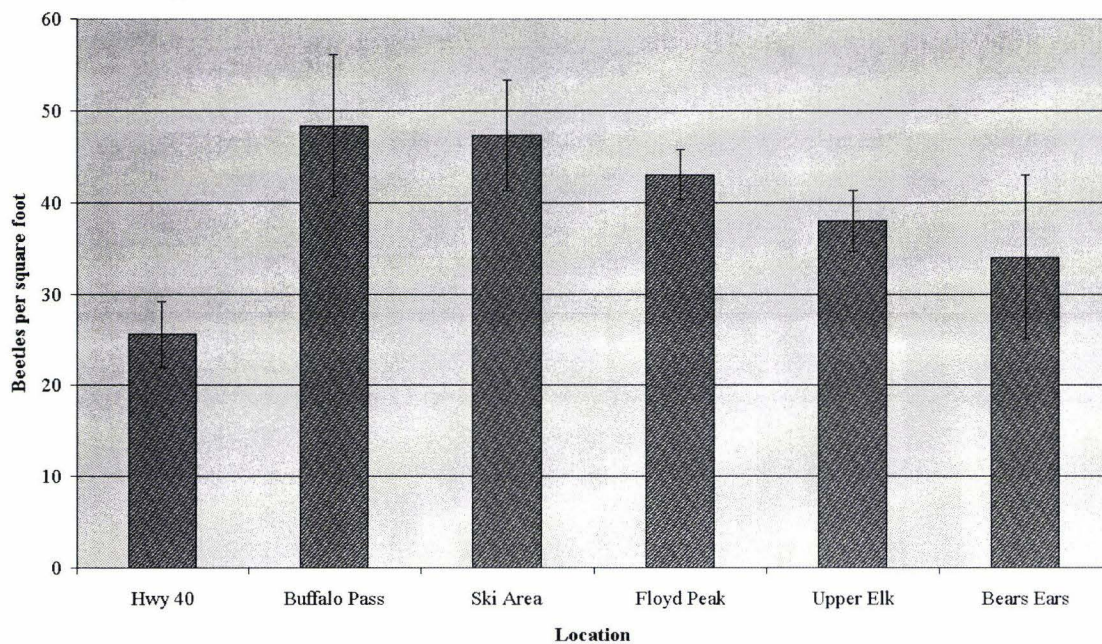
Such variation was evident even though brood sampling activities were expanded in 1999 to include more locations and more trees, as compared with 1998 (Schaupp et al. 1999). This is not surprising, however, as Schmid (1981) noted that more than 100 samples per surface were required to obtain a standard error of the mean within 20% of the average beetle brood value per square foot. None of the 1999 brood sample locations achieved this level of consistency, though some were close.

The variation in spruce beetle brood numbers within windthrow reflects different attack densities and survival rates. Brood density, though variable, was highest on the bottom surface and lowest on the top surface of windthrow (Table 4). Although not subject to statistical analysis, this consistent pattern is evident in Table 4 and reflects the beetles' well-known preference for shade. This result is consistent with published results (Schmid 1981). Several of the sample trees at the Highway 40 location were under a closed canopy in deep shade and, consequently, the density figures do not differ as widely by surface as they do at the more open locations such as Buffalo Pass (Table 4).

Overall, the spruce beetle brood densities by location for 1999 (Figure 3; bottom of Table 4) are within the upper range of data presented by Schmid (1981) for late summer samples, using his calculation method on both sets of numbers (see the second footnote on the bottom of Table 4 and “Biological Evaluation Procedures”, pg. 4, in Schmid 1981). This suggests that spruce beetle populations at many locations have the potential to become local epidemics in standing green trees.

Figure 3. Average Brood Density by Location

Figure 3. Average brood density of spruce beetles in windthrow, grouped by location on the Hahns Peak/Bears Ears Ranger District, Routt National Forest, Colorado, Fall 1999. Bars indicate standard error of the average.



In Schmid’s 1981 study, the three untreated spruce beetle populations, which either disappeared naturally or remained at low levels, had estimated average late summer brood densities per tree of 7.6, 20.5 and 24.4 beetles per square foot for the Mt. Graham, Philmont Ranch, and Hidden Valley populations, respectively. These averages are well below our 1999 results, with the possible exception of the Highway 40 location (Figure 3).

In that same study, four spruce beetle populations exhibited much greater densities. Schmid (1981) notes that, because of sanitation logging or chemical treatment, these denser spruce beetle populations did not reach severe outbreak status, although additional infestations did develop in two cases. Using the same calculation method noted above, the highest average brood density per windthrown tree for late summer samples was 118.3 and 58.2 beetles per square foot at Agassiz Park, AZ, in 1969 and 1970. Other late summer windthrown tree brood density estimates per square foot are as follows: 51.9 at Sierra Blanca, NM; and 30.5 at Iron Creek, WY. With the exception of the first sample date at Agassiz Park, AZ, the estimated windthrown tree brood densities found in 1999 in Colorado are well within the same range (Figure 3). By analogy to Schmid’s 1981 work, the spruce beetle populations in the Buffalo Pass, Ski Area, Floyd Peak, and Upper Elk locations have the potential to become severe outbreaks.

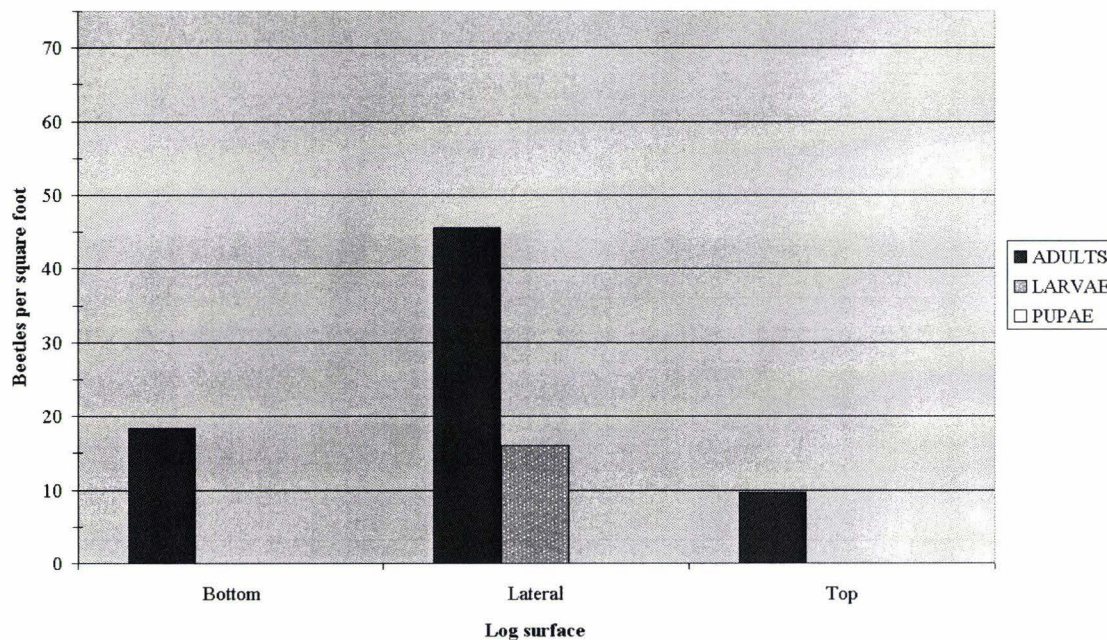
lateral surfaces. It also indicates a large resident population and underscores the potential for subsequent standing tree mortality at this location.

Another location that nearly meets this adult beetle density “standard” is the Upper Elk area. This is the location closest to the largest concentration of windthrow from the Routt Divide Blowdown. As Table 4 shows, this is a location will also require careful monitoring. Suppression or protection activities may be warranted to mitigate potential mortality to standing green spruce trees.

Another location that warrants careful monitoring due to the spruce population potential is the Bears Ears area in the Elkhead Mountains northeast of Craig. Results from 1999, shown in Figure 5, do not meet the “standard” of 45 adults per square foot on the bottom surface, but did reach this average density on the lateral surface. That only five trees were sampled precludes any conclusions, but serves to add this location to the growing list of spruce beetle “hot spots” identified by brood sampling.

Figure 5. Brood Density by Log Surface and Life Stage, Bears Ears

Figure 5. Sample density of spruce beetles in 5 windthrown trees in late summer 1999 by log surface and life stage, Bears Ears area, Routt National Forest, Colorado.



This same tree with the emergence cage was used for brood sampling. A 6 X 6 inch lateral sample was taken from under the caged portion of the stem and it contained 14 adult spruce beetles, which equates to 64 adult beetles per square foot. The bottom sample had 12 adults and the top sample had no spruce beetles.

An alternative explanation for finding "one year" beetles in the field is that they actually were "two year" beetles that developed for one year within a tree that was attacked when standing in 1997 and subsequently blew over in late 1997. If a standing tree was infested before the 1997 windthrow event, one would expect relatively similar densities on the top, lateral, and bottom surfaces, because the tree would have to have been attacked when standing and would presumably have had similar shading on all stem surfaces, as compared with a windthrown tree.

A strongly uneven distribution of beetles on windthrown tree surfaces, with few to no spruce beetles on the top surface, was observed on the windthrown tree on Buffalo Pass that had an emergence cage attached to it. This was also the case at several locations in the field in late summer 1998 (Schaupp et al. 1999). This evidence reinforces the conclusion that the windthrown trees with "one year" beetles were not attacked when standing and did have spruce beetles infesting them that developed within one year. Therefore, this one windthrown tree on Buffalo Pass contained both "one year" spruce beetles that emerged in 1999 and "two year" spruce beetles that will emerge in 2000. Such an occurrence has been documented elsewhere with spruce beetle (Safranyik and Linton 1999).

DISCUSSION

ENDEMIC STATUS IN STANDING TREES

Spruce beetle activity has been at low levels in standing trees since at least 1994 on the Hahns Peak/Bears Ears Ranger District and surrounding areas. No substantial spruce beetle activity was detected during aerial surveys in 1996, 1997, and 1998 (summarized in Schaupp et al. 1999). Further, 1999 aerial surveys located very few spots of spruce mortality and all of them were small. The visual signature of spruce fading from spruce beetle attack is one of the most difficult of all to see from the air. However, it is highly unlikely that substantial activity would be missed by aerial survey. And, despite all the casual and formal ground survey activity, only a few green, currently infested, standing spruce trees were located during the summer of 1999. However, 1999 brood samples indicate that the level of spruce beetle activity in standing, green spruce will be increasing. This increase will start in 2000 when spruce beetle populations begin to exit the windthrow.

BEEPLES BEGINNING TO EXIT WINDTHROW

The 1998 spruce beetle biological evaluation speculated that the pheromone traps would not capture significant numbers of spruce beetles in a given location until there was a reduction in available, attractive windthrow (Schaupp et al. 1999). The pheromone traps were suggested as an "inverse indicator," capturing spruce beetles when the "competition" from fresh windthrow had been reduced, when spruce beetle populations must search extensively for host material. Such a time may be when the spruce beetle population moves out of the windthrow, beginning to attack standing spruce. The pheromone trap catch in 1999 was consistent with this notion.

The 1999 pheromone trapping totals contrast sharply with the 1998 results, when 14 traps at seven locations caught a total of three spruce beetles (Schaupp et al. 1999). Note that the seven locations used in 1998 were also used in 1999, with the exception that the Walton Creek traps were placed near the Walton Creek Blowdown in 1998 and near the Walton Creek Campground about a mile away in 1999. At all but one location, the 1999 trap catch exceeded the trap catch of 1998. The population trend at a given location is probably reflected by relative trap catches in successive years. However, the actual number of beetles captured by a trap in one year has no fixed interpretation.

TIMELY SUPPRESSION OF BEETLES IN “HOT SPOTS”

A primary purpose of brood sampling is to determine which life stage of spruce beetle is predominant within the windthrow. Where adults are the most common life stage in late summer brood samples, one can comfortably conclude that the following spring and early summer will witness a flight of attacking beetles exiting the windthrow. This is because, in locations where no additional windthrow is suitable or available, the spruce beetles will attack standing, green trees. In late summer brood sampling, it was determined that this condition was the case at Buffalo Pass and that other areas might experience similar results.

In response to the growth in spruce beetle populations, Medicine Bow – Routt National Forest staff and ski area employees engaged in direct control activities at Buffalo Pass, the Steamboat Springs Ski Area, and the Highway 40 corridor. These were all areas identified through analysis as being of concern with respect to spruce beetle activity in standing, green trees. Infested windthrow was burned or peeled. Using Schmid's biological evaluation procedures (Schmid 1981), we calculated the potential number of infested standing trees that could result from the spruce beetle brood that was sampled in the windthrow patch nearby. As Table 5 shows, this effort may have saved a large number of trees.

Schmid (1981) points out the conservative nature of this calculation. There are a number of simplifying assumptions made to ease calculation and get at the desired result, which is knowledge of where spruce beetle populations can be expected to kill significant numbers of standing green trees. At risk are those susceptible trees immediately adjacent or within ¼ mile of infested windthrow. By taking this action when and where they did, land management personnel prevented additional spruce mortality within the treated areas. Such a preventive action could not be taken any later, as the beetles would have already exited the windthrow.

The preventive actions may not be a permanent solution, however. The areas treated by the control work may be inundated in a few years by spruce beetles immigrating from nearby, uncontrolled infestations, killing the “saved” standing trees. Until such time, the value of the suppression treatment remains effective.

Table 5. Effects of Treatments in 1999

Table 5. Estimated number of standing spruce trees that would have been killed in 2000 by spruce beetles emerging from windthrow at several locations on the Routt National Forest, Colorado, using the method of Schmid (1981)*. Timely treatment of the windthrown trees may have prevented the estimated mortality by killing the beetles within them.

Location	N = Trees sampled	Total attacking spruce beetles *	Treated trees	Beetles destroyed **	Estimated number of trees that would be killed ***	
					Frye et al. (1977)	Knight (1960)
Hwy 40	12	49387	250	1028896	1620	907
Buffalo Pass	9	53517	1000	5946348	9364	5239
Ski Area	18	82374	385	1761886	2775	1552
Floyd Peak	11	84498				
Upper Elk	21	153867	20	146540	231	129
Bears Ears	5	40382				
					13990	7827

* Calculated per sampled windthrown tree as follows: $[(SB \text{ bottom} + (2 \times SB \text{ lateral}) + SB \text{ top})] \times [L \times D \times 3.1416] =$
[sample density of spruce beetles per square foot] $\times$ [infested windthrow surface in square feet]
and totalled for all sampled windthrown trees per location, WHERE

SB bottom is the number of spruce beetles found in a 6 X 6 inch sample taken from the bottom surface of windthrow

SB lateral is the number of spruce beetles found in a 6 X 6 inch sample taken from the lateral surface of windthrow

SB top is the number of spruce beetles found in a 6 X 6 inch sample taken from the top surface of windthrow

L is the measured infested length of the windthrown tree in feet, exclusive of the first and last 5 feet
of the stem and of a diameter greater than or equal to 10 inches

D is the diameter in feet at mid-point of the infested length

3.1416 is an approximation of the constant π

Schmid, J. M. 1981. Spruce beetles in blowdown. USDA Forest Service, Rocky Mtn. For. Rng. Expt. Stn., Res. Note RM-411, 5 p.

** Calculated as follows: $[\text{Trees treated}/\text{Trees sampled}] \times [\text{Total attacking beetles from N trees}]$

*** Calculated using the number of beetles destroyed and the number of beetles to cause mortality of a spruce tree 16 inches in diameter at breast height, which is the estimated average stand diameter in these locations. Citations are contained in Schmid (1981) and refer to two separate studies.

2. Take a stand against the realistic “worst-case” scenario.
 - This is in progress. An interdisciplinary team is developing a “bark beetle” environmental impact statement for an analysis area that includes the Hahns Peak/Bears Ears Ranger District and part of the Parks Ranger District. This planning document is unique in that it concerns an analysis area before an imminent bark beetle epidemic is in full swing, rather than reacting to unacceptable levels of ongoing mortality. The rare opportunity to learn about these infrequent, large scale disturbance events as matters progress is an integral part of the planning effort, as an adaptive approach to management decisions is being taken. This document lays out alternative actions in the face of the uncertainty of future events, prepares the beetle “tool kit,” and lays out the approaches for applying the tools against the beetles, where that is deemed appropriate. Most important, this effort has identified the areas that will be negatively impacted by mortality caused by spruce (and mountain pine) beetle. Together with the “hazard” map and evaluations of current conditions, this will allow decisions as to where actions should be taken that have a good chance of success. Implementation of this plan will fulfill this recommendation.
3. The salvage or removal of as much blowdown material as practical will reduce the host reservoir for the spruce beetle.
 - This has been in progress for some time now. Timber contracts have been initiated and windthrown trees continue to be removed from the Medicine Bow – Routt National Forest.
4. In areas where timber salvage activities occur, take site-specific measures to provide additional monitoring and mitigation.
 - Recommended actions were trap trees and additional pheromone monitoring traps where timber salvage activities have occurred. This has been implemented at the Sawmill Timber Sale area and where suppression activities were taken last year.
5. In ecologically sensitive areas, other types of treatments might be considered that would make downed spruce unsuitable for breeding material or would kill the current population of beetles infesting logs.
 - See the section **“TIMELY SUPPRESSION OF BEETLES IN “HOT SPOTS”** in the “Discussion” section for actions taken already that involve windthrow infested by spruce beetle. Thousands of trees may have been saved already. This effort is slated to continue. With the recently successful registration of MCH, an “anti-aggregant” pheromone of spruce beetle, protection of sensitive areas may be possible (see Appendix 1 for discussion of MCH). Recent studies in Utah have shown, however, that MCH is an ineffective treatment when spruce beetle populations have already reached epidemic status. It is therefore important to employ MCH as a tactic when beetle populations have yet to attain epidemic status.
6. Continue, in association with Forest Health Management, to survey, evaluate, and monitor spruce beetle populations.
 - This will continue as long as needed. An entomologist has been reassigned to the bark beetle project on the Medicine Bow – Routt National Forest from the Rocky Mountain Region’s Lakewood Service Center. Aerial and ground survey, brood sampling, and other monitoring activities are expected on an annual basis.

APPENDIX 1

ACTION ALTERNATIVES AGAINST SPRUCE BEETLE

by C. Kendall Lister, W. C. Schaupp, Jr., M. S. Frank, and S. Johnson

MANAGEMENT STRATEGIES

Forest managers can develop various strategies to avoid or reduce resource losses to spruce beetles. Before developing a strategy, the forest manager must evaluate the resource values and economics of management actions for each stand in light of management objectives. The beetle population level must also be considered, because population levels will determine the priority of management actions and the type of strategy to be invoked. Landscape considerations are important, because both stand susceptibility and beetle population levels in adjacent and nearby stands will influence events in stands under consideration.

The primary strategy should be silvicultural treatments of potentially susceptible stands in order to maintain their health with a moderate growth rate. These silvicultural strategies should be implemented well in advance of an epidemic. The first step in this strategy is to risk-rate spruce stands, which will indicate the most susceptible stands and areas where susceptible stands are concentrated. The stands can then be treated with harvesting directed at the most susceptible stands and areas. Infested logging residuals seldom become a significant contributor to spruce beetle populations if stump height is kept below 18 inches (45 cm) and cull logs and tops are limbed, cut into short lengths, and left unshaded, unpiled, and exposed to sunlight. Silvicultural treatments have greater long-term effectiveness, because these treatments modify stand conditions.

The primary strategy assumes, in general, beetle populations are not immediately threatening resource values. If beetle populations are threatening, then strategies involving suppression are more appropriate. Suppression methods including silvicultural, physical and chemical measures are available to forest managers for reducing spruce beetle populations. Some methods are suitable only for populations in windthrown host material; other methods are better suited for infestations in standing trees. Most suppression methods are short-term responses to existing beetle populations and, therefore, correct only the immediate situation (Holsten et al. 1999).

A long-term goal of reducing susceptibility to spruce beetle involves creating a mosaic of age classes and stand conditions across entire landscapes. Without substantial interference, each major spruce beetle epidemic sets the stage for the epidemic to be repeated, as the forest regenerates and grows again into a susceptible condition. Because landscape-level spruce beetle epidemics are rare, the opportunity exists to modify landscape conditions in areas where these large beetle-caused disturbances conflict with management objectives. In this way, major spruce beetle epidemics may not necessarily be repeated in the distant future.

TREATMENT OPTIONS

SILVICULTURAL TREATMENT

Silvicultural practices and priorities can be developed if clear and well-defined management objectives exist. In determining treatment or cutting unit priorities, spruce beetle susceptibility should be integrated with all the other treatment objectives to best attain management goals and objectives. Three stand ratings, utilizing the potential outbreak rating or risk, provide guides that should be used in determining overall stand treatment priorities.

1. High. Susceptibility to attack and damage is a primary concern in reaching or maintaining management objectives where the potential spruce beetle risk is high or medium. This concern may be addressed by evaluation of probable spruce beetle population trends, possible impacts, and so forth, conducted by pest

trees at high risk to bark beetle, damaged trees, trees already infested, or poor vigor dominants and codominants. Where more than the recommended basal area to be removed is in high risk trees, a decision of whether to accept the risk of spruce beetle attacks or to accept the risk of windthrow by removing additional susceptible trees will have to be addressed (Alexander 1986). Two or three entries may be required to meet the desired condition (Alexander 1986).

Uneven Aged Regeneration Cutting Methods

In situations where stands are clearly irregular in structure, maintaining the irregular stand structure is desirable, and the risk to spruce is apparent and undesirable, selection or group selection cutting methods are applicable. Selection regeneration methods may have advantages in managing spruce beetle susceptible stands in these situations by allowing regulation of stocking, basal area, and controlling diameter distribution while maintaining stand characteristics valuable to management objectives.

No specific information or guidelines are available on the implementation of uneven-aged cutting methods in spruce beetle susceptible stands. Multiple entries may be required to achieve the desired stocking and diameter distribution. However, where visual quality is important, suggested stand structure objectives could be a growing stock level of 100 to 120 sq. ft. of basal area on most sites, a maximum tree diameter of 24 inches, and a diameter distribution approaching a Q of 1.3 to 2.0 (Alexander and Edminster 1977). Where lowered susceptibility to spruce beetle is needed, fewer large diameter trees are desirable, so that an average stand diameter less than or equal to 12-14 inches for spruce is suggested. As with commercial thinning, the improved stand vigor and modified habitat conditions which would result from cutting in uneven aged stands is predicted to lower stand susceptibility to spruce beetle attack and tree killing.

Minimizing Spruce Beetle Build-up in Logging Slash and Debris

The following guidelines can be utilized to minimize spruce beetle population increases in logging slash and debris:

- A. Cut trees as low to the ground as possible, preferable stump height of no more than 12 inches.
- B. Cull logs and larger diameter slash material can be used to "trap" beetles to further reduce populations and lessen the risk of attack to standing trees, if this material is left in the cutting unit and then removed or treated after beetle flight. This trap material must be removed prior to the next beetle flight. If they are not removed, beetles produced in this material will increase the chance of attacks to surrounding standing spruce (Schmid 1977). Utilize C-Provisions, R0-C-6.46, R0-C6.47, R0-CT-6.46, and R0-CT-6.47 as deemed necessary.

CULTURAL TREATMENT

Trap Tree Method

Trap trees are green trees with a diameter greater than 18 inches d.b.h that are felled, preferably before the spring beetle flight (Holsten et al. 1999). Trap trees should be left in their "natural state" with no limbing being done, because the limbs shade the bole and make the trees more attractive to spruce beetles in this condition. Trap trees are used to attract and decoy emerging beetles away from living, standing green spruce trees. Traditional trap tree usage is more effective for absorbing beetles than baiting standing green trees for the following reasons: 1) beetles prefer downed material over standing green trees; 2) beetles infest a greater percentage of the bole; and 3) the mean attack density is greater. Once the trap tree is infested with beetles, it must be treated by milling, burning, solar heating, or insecticidal application (Schmid and Frye 1977).

Trap tree treatment considerations to be aware of are as follows: beetles are effectively attracted up to one-quarter mile from the felled tree, becoming less effective with an increase in distance; trees felled in the shade are preferred over those felled in the sun (Nagel et al. 1957); and trap trees, by attracting beetles, may lead to attacks on standing spruce adjacent to them. Unbucked trees provide more shade, increasing beetle suitability and reducing both fungal development and competition from *Ips* species, because branches provide increased shade and serve to hold the bole above ground. By keeping the bole off the ground, more of the shaded underside is available for colonization. The number of trap trees felled is relative to the attacking beetle population and the size of the felled host. A trap tree may absorb 10 times the number of beetles a standing tree will absorb (Schmid

In general, the use of attractant pheromones does not constitute a treatment tactic on its own, but is employed to augment silvicultural treatments or trap tree methods. For example, to retain or bring beetles into an area scheduled for a regeneration cut, one could place tree baits in the stand to be treated. Similarly, one can place tree baits containing attractant pheromone on trap trees or lethal trap trees to render them more attractive. It must be stressed that spillover attacks on trees adjacent to those baited is a common occurrence. Failure to treat baited and adjacent attacked trees in a timely manner can lead to exceptionally high tree mortality.

Tree mortality from spruce beetle might be reduced by deploying the spruce beetles' repellent pheromone prior to the attack period. The natural repellent pheromone or anti-aggregant pheromone of the spruce beetle is MCH or 3,2-MCH (3-methyl - 2-cyclohexen - 1-one). As colonization of a tree proceeds, the amount of MCH released into the air increases. Apparently, a certain threshold of MCH signals to other beetles that the tree is fully occupied and no longer suitable for colonization. Beetles searching for host material are thus repelled by such trees and search elsewhere for suitable material.

MCH has been used successfully to disrupt attack and colonization by spruce beetle in host trees and shown to reduce the attraction of spruce beetles on infested logs. In addition, MCH has recently been shown to be effective in preventing attack by Douglas-fir beetle (*Dendroctonus pseudotsugae*) on small, valuable stands of Douglas-fir. However, equivocal results in recent trials in Utah suggest that operational use of MCH against spruce beetle cannot be universally successful in all areas or.

A potential use of MCH would be to deploy MCH in an area in an attempt to disrupt attack and colonization there, causing dispersal of beetles. This would be done with methods similar to those used against Douglas-fir beetle. It may be that this tactic is only successful at lower beetle population levels and that effectiveness ceases above some population threshold. Another potential use of MCH would be deploying it to "push" spruce beetles from a stand or area needing protection while at the same time "pulling" them into a nearby stand or area scheduled for regeneration harvest with attractant pheromones. Neither of these tactics has been successfully demonstrated against spruce beetle as yet.

One inhibition to the development of operational MCH use has recently been eliminated. MCH is currently registered for use in the United States by the USDA Forest Service under the authority of the US Environmental Protection Agency. Not all States, however, have reviewed this recent development and given their approval.

REFERENCES

- Alexander, R.R. 1986. Silvicultural systems and cutting methods for old-growth spruce-fir forests in the central and southern Rocky Mountains. *USDA Forest Service, General Technical Report RM-126*, 33 pgs. Rocky Mountain Forest and Range Experiment Station, Ft. Collins, CO.
- Alexander, R.R. and C.B. Edminster. 1977. Uneven-aged management of old growth spruce-fir forests: Cutting methods and stand structure goals for the initial entry. *USDA Forest Service Research Paper RM-186*, 12 pgs. Rocky Mountain Forest and Range Experiment Station, Ft. Collins, CO.
- Bentz, B.J. and A.S. Munson. 2000. Spruce beetle suppression in northern Utah. *Western Journal of Applied Forestry* 3 (15): 122-128.
- Schmid, J.M. 1977. Guidelines for minimizing spruce beetle populations in logging residuals. *USDA For. Ser. Res. Pap. Rm-185*, 8 pgs. Rocky Mountain Forest and Range Experiment Station, Ft. Collins, CO.
- Schmid, J.M. and R.H. Frye. 1976. Stand ratings for spruce beetle. *USDA For. Ser. Res Note RM-309*. 4 pgs. Rocky Mountain Forest and Range Experiment Station, Ft. Collins, CO.
- Schmid, J.M. and R.H. Frye. 1977. Spruce beetle in the Rockies. *USDA For. Ser. Gen. Tech. Rep. RM-49*, 38 pgs. Rocky Mountain Forest and Range Experiment Station, Ft. Collins, CO.
- Skillen, E. L., C. W. Berisford, M. A. Camann and R. C. Riordan. 1997. *Semiochemicals of forest and shade tree insects in North America and management applications*. USDA For. Serv., For. Health Tech. Enterprise Team FHTET-96-15, Morgantown, WV. 182 pgs.
- Smith, D.M. 1986. *The Practice of Silviculture*, 8th Ed. John Wiley and Sons, Inc. N.Y. 578 pgs.